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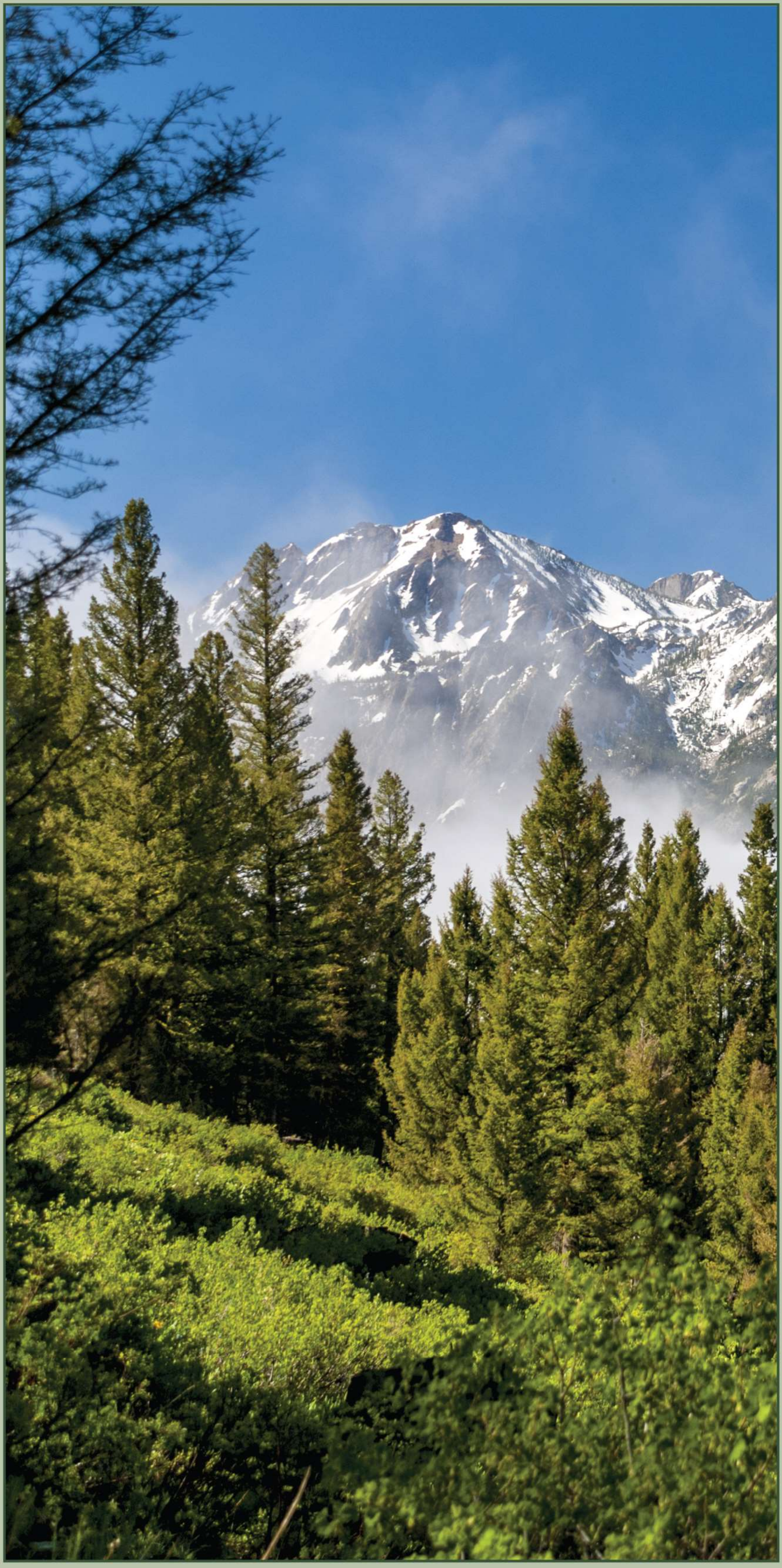
SAWTOOTH NATIONAL FOREST



MID-LEVEL EXISTING VEGETATION CLASSIFICATION AND MAPPING

December 2015

SAWTOOTH
NATIONAL FOREST

Forest Service
Intermountain Region

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Executive Summary

Existing vegetation classification, mapping, and quantitative inventory (VCMQ) products for the Sawtooth National Forest (SNF) were developed to help better understand the spatial distributions of vegetation types, structural classes, and canopy cover. These products were developed collaboratively with the SNF, the Remote Sensing Applications Center (RSAC), the Intermountain Regional Office (RO), and the Interior West Forest Inventory and Analysis (IWFIA) program. The final maps align with the Existing Vegetation Classification, Mapping, and Inventory Technical Guide (Nelson et al. 2015). The vegetation maps comprise 30 vegetation types, eight canopy cover classes for trees and shrubs, and four tree size classes for forest and woodland types. An accuracy assessment was completed to help users quantify the reliability of the map products and support management decisions that use this information. The existing vegetation products discussed in this document will help users to better understand the extent and distribution of vegetation characteristics for mid-level planning purposes, and disclose the methods and accuracies of these products. The SNF mid-level existing vegetation project is one among many VCMQ Forest projects currently being completed in the Intermountain Region.

Introduction

Existing vegetation classification, inventory, and mapping was completed on over 2 million acres of the Sawtooth National Forest (SNF) in Idaho and Utah to standards established by the Intermountain Region Vegetation Classification, Mapping, and Quantitative Inventory (VCMQ) team and outlined in the Existing Vegetation Classification, Mapping, and Inventory Technical Guide (Nelson et al. 2015). The purpose of the project was to provide up-to-date and more complete information about vegetative communities, structure, and patterns across the SNF landscape. Fulfilling this purpose is important in measuring compliance with National Forest Management Act (NFMA) obligations such as providing for a diversity of vegetation and associated habitat for terrestrial wildlife species.

Some resource management applications of the existing vegetation products may include ecosystem and wildlife habitat assessments, rangeland and watershed assessments, fuel load assessments, benchmark analysis, range allotment management plan updates, threatened and endangered species modeling, and recreation management. This document provides an overview of the methods, products, and results of classification, inventory, mapping, and accuracy assessment activities that were completed for the SNF.

Region 4 VCMQ Objectives

The Intermountain Region (Region 4) has identified the development of vegetation map products and associated inventory and classification work as one of its highest priorities since 2008. The goal of this effort has been to facilitate sustaining or restoring the integrity, biodiversity, and productivity of ecosystems within the Region by providing a sound ecological understanding of plant communities and their composition and structure.

Specific goals are to:

i. Help our forests continue to manage the lands according to their land management plans
ii. Provide the public with an initial classification, inventory, and map of mid-level existing vegetation in the Intermountain Region
iii. Establish a baseline of landscape ecological conditions, including vegetation type, tree size, and canopy cover distributions and locations throughout the Region

iv. Establish consistent methodologies and standardized data that meet best available science requirements, eliminate redundancies, leverage consistency, save money, and establish a framework for future activities
v. Develop scientifically credible products that meet business requirements at multiple scales and for multiple purposes
vi. Develop an update and maintenance program to ensure decisions are made based on the best available information

Intended Uses

The products discussed in this document can be used to address a variety of important land management issues related to watersheds, forest characteristics, rangelands, fuel loads and wildlife habitat. Feasible applications include resource and ecosystem assessments, species habitat modeling, benchmark analysis, design of monitoring procedures, and a variety of other natural resource analysis applications. Specifically for the SNF, the products will be useful for habitat assessments, grazing analyses, planning large-scale fuel reduction projects, landscape-level post-fire restoration projects, providing information to the public, and Forest Plan revisions. These products may provide information for targeting areas requiring investigation for potential projects or determining where more detailed studies are needed. Additionally, data collected during this effort may feed into broader-level analyses, such as determining estimates of nation-wide biomass, analyzing climate change responses, or mapping land cover.

Business Needs Requirements

The development of existing vegetation classification, inventory, and map products is at the heart of our Agency's mission (http://www.fs.fed.us/about-agency/what-we-believe), "Our mission, as set forth by law, is to achieve quality land management under the sustainable multiple-use management concept to meet the diverse needs of people." One mission activity that is directly related to the development of vegetation products is identified as "developing and providing scientific and technical knowledge aimed at improving our capability to protect, manage, and use forests and rangelands."

More recent Forest Service initiatives strengthen the need for acquiring existing vegetation information for our Forests and Grasslands. The National Forest System Land Management Planning Rule (36 CFR Part 219) Subpart A—National Forest System Land was published in the Federal Register on April 9, 2012, and became effective 30 days following the publication date. The new planning rule establishes "ecological sustainability" as a primary objective in forest management, and addresses “conservation of water flow and assurance of a continuous supply of timber as set out in the Organic Act, and the five objectives listed in the Multiple-Use Sustained Yield Act of 1960 (Public Law 86-517): outdoor recreation, range, timber, watershed, and wildlife and fish.”

Included in the new planning rule regulations, the plan monitoring program addresses the applicability of eight requirements per 36 CFR 219.12(a) (5). The SNF’s existing vegetation effort addresses three of the eight plan monitoring program requirements: 1) the status of select watershed conditions, 2) the status of select ecological conditions including key characteristics of terrestrial and aquatic ecosystems, and 3) the status of a select set of the ecological conditions required under §219.9 to contribute to the recovery of federally listed threatened and endangered species, conserve proposed and candidate species, and maintain a viable population of each species of conservation concern.

The 2012 planning rule also requires the responsible official to use the “best available scientific information” to inform the assessment, the development of the plan (including plan components), and the monitoring program. The planning rule requires that responsible officials document how the best available scientific information was used.

More recently, the Forest Service has developed a draft strategy for inventory, monitoring, and assessment (IM&A) activities as directed in the Forest Service Manual (FSM-1940). The strategy establishes a comprehensive approach for conducting IM&A activities in the agency that responds to our priority business requirements. The draft IM&A strategy lists existing vegetation as a sidebar for the strategy, and includes the statement “Existing vegetation, for example, is the primary natural resource managed by the Forest Service and is the resource on which the agency spends the most money for inventories and assessments” (USDA Forest Service 2013).

The SNF existing vegetation mapping project attempts to meet the requirements, policy, and guidelines for properly managing our Forests through standardized protocol development and implementation, data standardization, reliable data processing, defensible methodologies, and full disclosure. These policy, guidelines, and requirements establish the collection of existing vegetation information and mapping products as a requisite to proper land management in the area.

General Characteristics of the Area

The Intermountain Region of the Forest Service encompasses nearly 34 million acres of the National Forest System. This region contains 12 Forests in the states of Idaho, Utah, Nevada, Wyoming, Colorado, and California where four major geographic provinces come together (i.e., Great Basin, Colorado Plateau, Northern Rocky Mountains, and Middle Rocky Mountains). This geographic diversity is one reason for the Region's variety of ecosystems and landscapes. The Intermountain Regional Office in Ogden, Utah, provides administrative support for the Region's National Forests and Grasslands.

The SNF spans over 2.1 million acres in central and southern Idaho and northern Utah (**Figure 1**). The Forest comprises the Fairfield, Ketchum, and Minidoka Ranger Districts, and the Sawtooth National Recreation Area. The Forest Supervisor's Office is located in Twin Falls, Idaho.

The SNF is located on two geographic units separated by the Snake River Plain. The northern two-thirds of the forest consist of granite mountains that are part of the Idaho Batholith. The southern one-third of the forest in southern Idaho and northern Utah is part of the basin and range province. Elevations on the forest range from 4,514 feet up to 12,009 feet. Grasslands, shrub-steppe, and pinyon-juniper vegetation dominate lower and mid-elevations, and conifer forests dominate higher elevations. Within the conifer forests, ponderosa pine and Douglas-fir dominate lower elevations; lodgepole pine, Engelmann spruce, and subalpine fir occupy mid-elevations; and whitebark pine dominates higher elevations (McGrath et al. 2002, McNab et al. 2005, Steele et al. 1981).

Summers are generally hot and dry, and winters are generally cold and snowy. Precipitation across this semi-arid ecoregion varies according to altitude, and the majority of annual precipitation occurs as snow from late fall through early spring. A variety of soil types exist throughout the SNF: volcanics, quartzites, granitics, sedimentary rocks, and alluvial deposits (Steele et al. 1981). Over 1,100 lakes and 3,500 miles of rivers and streams are found throughout the Forest. Major river systems on the SNF include the Salmon, South Fork of the Boise, South Fork of the Payette, and the Wood River.

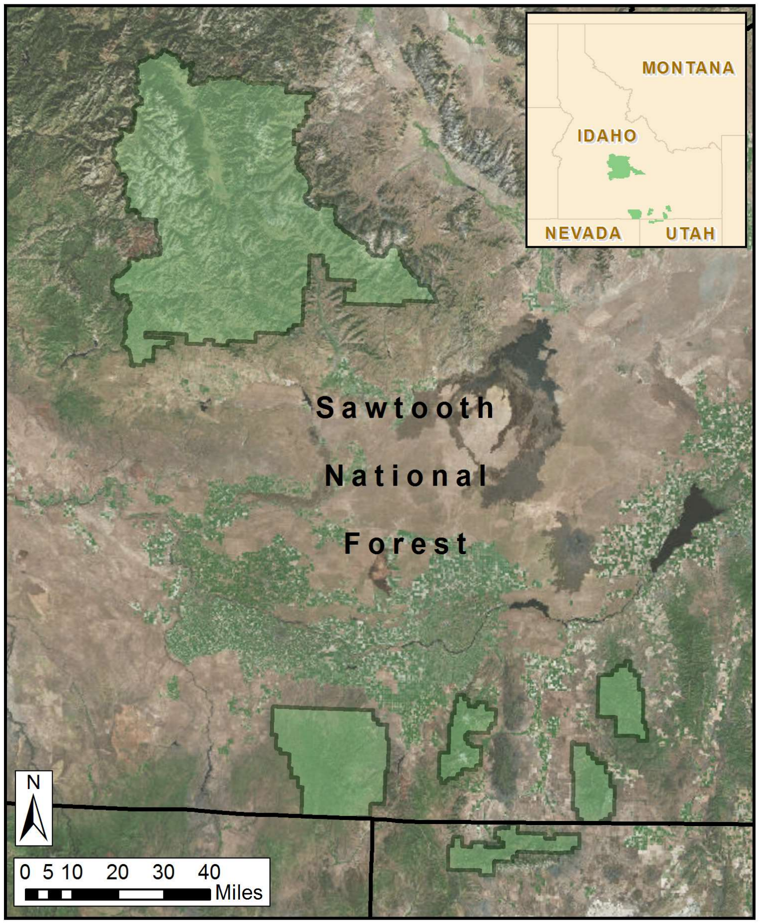

Figure 1: The Sawtooth National Forest, located in Idaho and Utah, stretches over 2.1 million acres.

Partnerships

The mid-level existing vegetation products were collaboratively planned, developed, and implemented by technicians and experts within the Forest Service. These partnerships were critical to ensuring the highest level of integrity, objectivity, and usefulness for internal uses such as landscape assessments, and for external consumption by the public. The primary participants in the development included SNF and Regional Office staffs, the Remote Sensing Applications Center (RSAC) and the Interior West Forest Inventory and Analysis (IWFIA) Program of the Rocky Mountain Research Station (**Figure 2**).

The Intermountain Regional Office established the VCMQ core team in 2009 to create existing vegetation products for regional and forest-level uses, such as forest-planning-level analysis, broad-scale analysis, monitoring, assessments, and as a framework for project-level analysis. The team provides expertise in botany, ecology, forestry, soils, remote sensing, inventory and mapping, GIS, information technology, and program management.

The SNF is a primary stakeholder in the derived outcomes of this project since they administer the lands and use these products for land management activities. The SNF has collaborated on all aspects of the vegetation mapping project from the initial needs assessment to the final accuracy assessment. A focused group of forest resource specialists, contract specialists, and GIS specialists helped identify tasks and deliverables, made recommendations based on user needs, and served as Forest representatives to the collaborative effort. A broader audience of resource specialists and program managers reviewed draft map products, provided field-based knowledge, and offered suggestions to make the deliverables more meaningful from a Forest perspective.

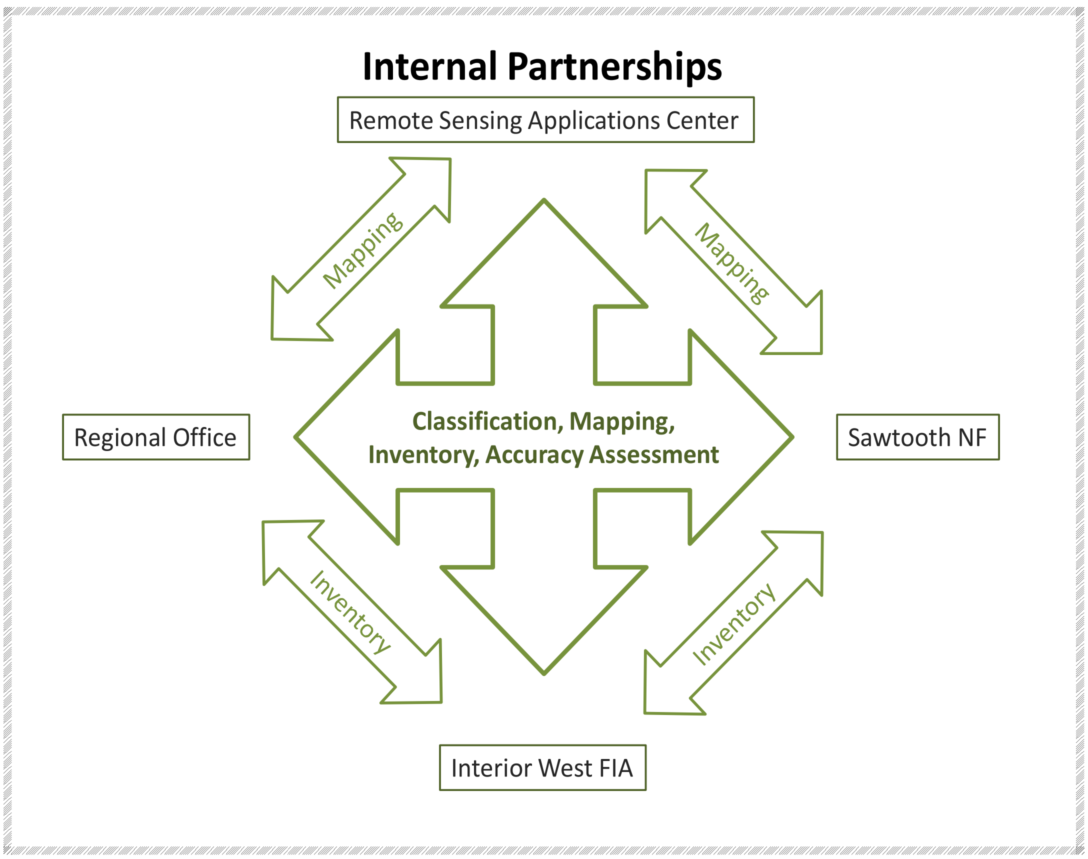

Figure 2: Partnerships developed for the classification, mapping, inventory, and accuracy assessment conducted on the SNF.

RSAC is a national technical service center of the USDA Forest Service. The mission of RSAC is to provide the Forest Service with the knowledge, tools, and technical services required to use remote sensing data to meet the Agency's stewardship responsibilities. RSAC's Mapping, Inventory, and Monitoring program provides operational remote sensing support and analysis services to help meet internal and interagency programmatic assessment and monitoring needs, such as this existing vegetation mapping project. RSAC is the principal provider of remote sensing technical expertise and map production techniques for this effort. The Center has assisted in this effort in all aspects: data collection, remote sensing analyses, image segmentation, image analysis, field reference data protocol and sample design, map filtering, map production, draft map reviews, and final report development.

The IWFIA unit operates under technical guidance from the Office of the Deputy Chief for Research and Development, located in Washington, DC, and under administrative guidance from the Director of the Rocky Mountain Research Station located in Fort Collins, Colorado. This research unit provides ongoing support for the inventory aspects of the project: FIA inventory on forest land and all-condition inventory (ACI) on nonforest plots, contract inspections, data collections, database assistance, pre-field inspections, intensified inventory sample design, and accuracy assessment. Their participation ensures consistency and establishes credible and defensible inventory data to be used in conjunction with the derived map products.

Final Products

The final map products depict continuous land cover information for the entire project area including the SNF and private land inholdings. Maps are formatted as a geodatabase, which is compatible with Forest Service corporate GIS software. The vegetation maps are consistent with mid-level mapping standards set forth in the Existing Vegetation Classification, Mapping, and Inventory Technical Guide (Nelson et al. 2015). In conformance with these standards, most modeling units were aggregated up to 5 acres; aspen, aspen/conifer, conifer/aspen, riparian woody, and riparian herbaceous vegetation types were aggregated to 2 acres. Additional products include field-collected reference information and photographs, seasonal Landsat image mosaics and derived vegetation indices, topographic derivatives, climate data, surface information derived from IfSAR, fire history, and burn severity information.

Methods

The phases for this project included project planning, data acquisition and processing, classification development, segmentation, map unit legend design, reference data collection, modeling, draft map review and revision, and final map development (**Figure 3**). After the final maps were completed, an accuracy assessment, vegetation type map unit description, and dominant type descriptions were developed.

Maps depicting existing vegetation types, canopy cover, and tree size classes were developed using moderate and high resolution imagery, topographic data, ancillary GIS layers, field and photo-interpreted reference data, automated image segmentation, and data-mining classification techniques. The remotely sensed imagery assembled for this project included moderate and high resolution satellite and aerial imagery. Eighteen Landsat scenes (30-meter spatial resolution) were assembled depicting spring, summer, and fall conditions. The high resolution imagery included 2011 National Agricultural Imagery Program (NAIP) aerial photography (1-meter) and 2009 resource photography (half-meter). U.S. Geological Survey Digital Elevation Models (DEM) (10-meter) were compiled. Other ancillary GIS layers that were gathered include climate, geology, wildfire severity, land systems inventory, and interferometric synthetic aperture radar (IfSAR) data[1].

Vegetation indices and image transformations were generated from the Landsat and high resolution imagery and topographic information was derived from the digital elevation models[2]. All imagery and topographic derived information were projected to a common geographic coordinate system (UTM, NAD83, and Zone 11 N). Modeling units (image segments) were developed using the resampled 2009 resource photography, Landsat data, and a topographic derivative.

Field sites were collected in homogenous modeling units during the summer of 2011 and information on vegetation composition, canopy cover, and tree size was recorded. Additional canopy cover reference information was obtained using photo interpretation methods.

Map unit labels (vegetation type, canopy cover class, and tree size class) were assigned to the modeling units using Random Forests (Breiman 2001). Random Forests is a method of automated computer classification and regression that uses reference and geospatial data to

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[1] See Appendix A: Acquired Geospatial Data for Mapping.

[2] See Appendix B: Vegetation Indices, Transformations, and Topographic Derivatives.

develop decision trees. Each map (vegetation type, canopy cover class, and tree size class) was developed individually using distinct reference data sets and geospatial data layers.

Draft maps were distributed to SNF resource specialists for review and final revisions were made based on the feedback. Maps were completed by aggregating and filtering the modeling units to the minimum map feature size. Aspen, aspen/conifer, conifer/aspen, riparian woody, and riparian herbaceous vegetation types were filtered to 2 acre minimum polygon size, while all other vegetation types were filtered to 5 acre minimum polygon size. An accuracy assessment was conducted and descriptions of the vegetation type map units were written.

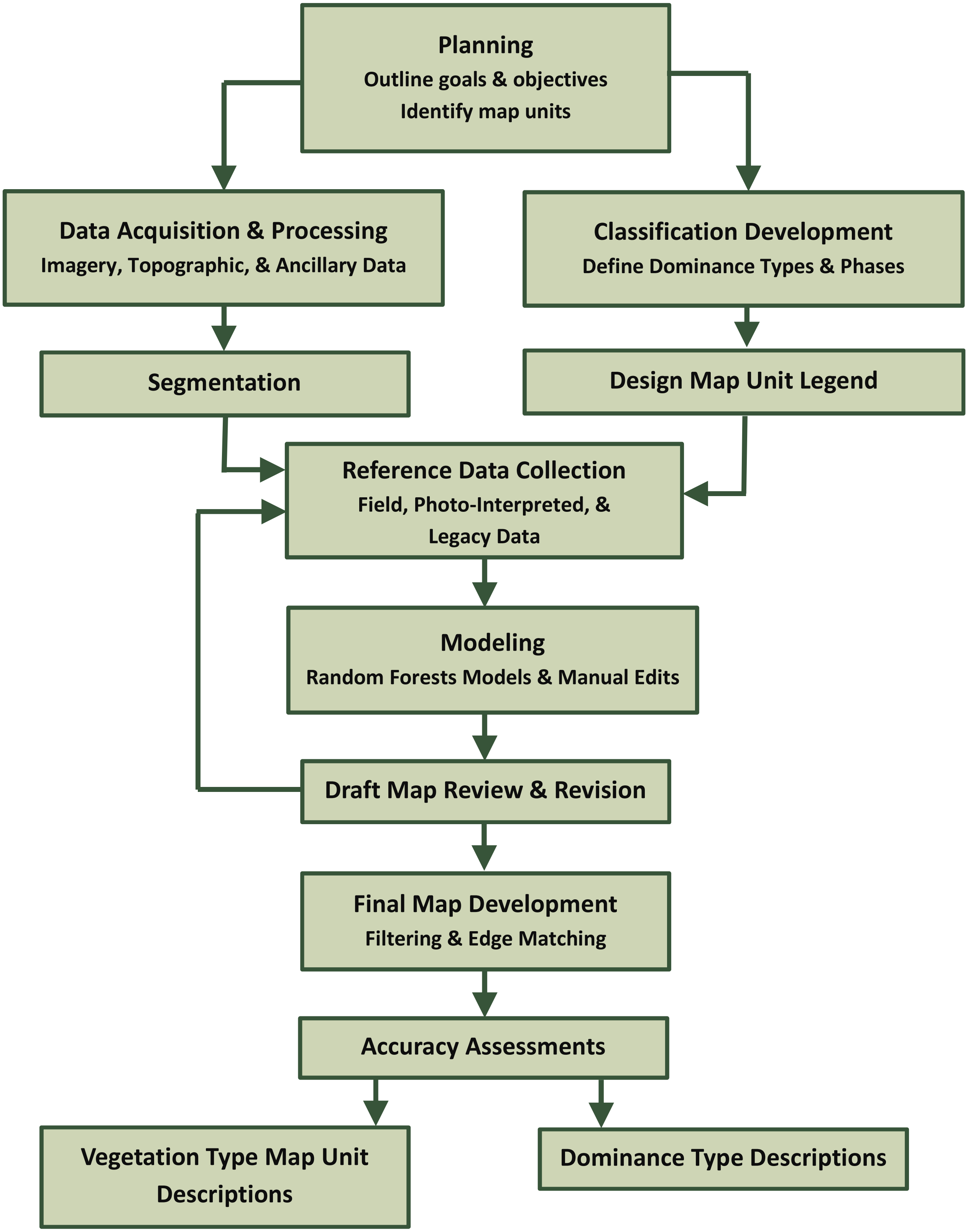

Figure 3: Project phases from project planning to descriptions of vegetation type map units and dominance types.

Project Planning

In 2011, staff of the SNF, Intermountain Regional Office, and RSAC met to discuss map unit design and prepare a project plan. Since one of the goals for the project was to provide a regionally cohesive map product, efforts were made to ensure that processes and spatial and thematic characteristics of the maps would fulfill regional requirements. A classification of dominance types and phases was developed to address forest information needs. These were combined into vegetation types that achieved a balance between map detail and accuracy within the allocated budget and time constraints. The final vegetation type map units conformed to the mid-level mapping standards referenced in the Existing Vegetation Classification, Mapping, and Inventory Technical Guide (Nelson et al. 2015), while the canopy cover and tree size map units were selected to represent the management needs of the Forest.

Vegetation Classification Development

The Intermountain Region's VCMQ program is designed to classify, map, and quantitatively inventory existing vegetation across the Region. At the regional level, existing plant communities are assigned to dominance types based on the most abundant species of the ecologically dominant life form (e.g., the most abundant tree species in forests or woodlands). This approach was decided upon by a council with representatives from each Forest in the Region.

At the Forest level, the regional dominance types may be subdivided into dominance type phases based on associated species of the same life form as the dominant species. Forests are able to define these phases to best meet their own information needs, as long as they nest within the regional dominance types.

An initial list of dominance types is compiled using Forest vegetation plot data and vegetation classification literature relevant to the Forest. The list is reviewed and augmented by Forest resource specialists and local contributors. The Forest specialists determine whether any dominance types need to be split into phases and how those should be defined. Rules for distinguishing phases are tested using the regional plot database and a taxonomic key to dominance types and phases is developed. In practice, phases have only been defined in forests and woodlands, not in shrublands or herblands.

Vegetation Type Map Units

Once the classification is developed, Forest and Regional specialists develop a map legend by determining which dominance types and phases should be mapped individually, and identifying which dominance types and phases can be combined. Overall map accuracy decreases as the number of map units increases; therefore, the team seeks to balance map detail versus map quality. This process is informed by applying the Forest dominance type key to FIA plot data and estimating the acreage of each type on the Forest. The initial map legend is complete when each dominance type and phase has been assigned to a map unit and included in the dominance type key[3].

Sawtooth Process

The above Regional process was followed to develop the dominance type classification and vegetation type map legend for the SNF (Tart et al. 2015)[3]. Data collected for classification of habitat and community types (Steele et al. 1981; Mauk and Henderson 1984; Tuhy 1981; Tuhy and Jensen 1982; Mueggler 1988; West el al. 1998) and vegetation plot data collected by the Idaho Conservation Data Center were used to compile a list of dominance types and test definitions of phases.

Structural Characteristics

Structural technical groups for tree size and tree and shrub cover were identified by SNF resource specialists to meet business information requirements specified in the land and resource management plans (Forest Plans). Tree size and canopy cover technical groups were established to represent a diversity of vegetation structure and density classes appropriate for informing the management and maintenance of physical and biological processes. The identified classes facilitate the assessment and monitoring of forest and nonforest (rangeland) vegetation, ecological patterns and processes, and wildlife habitat. In identifying structure and density map classes, considerations were also made related to the feasibility of mapping the identified categories using mid-level remote sensing mapping techniques.

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[3]See Appendix C: Existing Vegetation Keys.

Tree Size Class

Tree size class or tree diameter class is any interval into which a range of tree diameters may be divided for classification (Helms 1998). Tree size is represented by the plurality of a given class forming the uppermost canopy layer as viewed from above. Tree size classes (**Table 1**) for the Conifer Forest and Deciduous Forest vegetation group map units and the Woodland vegetation group map unit do not differ in individual diameter class breaks, but rather in the methods used for measurement. Forest species are measured using diameter at breast height (DBH) (4.5 feet above the ground) and designated woodland species (**Table 2)** are measured using diameter at root collar (DRC). Specific procedures used for measuring DRC are found in the Field Reference Data Collection Guide[4].

Table 1: Tree size map classes represented by diameter at breast height (DBH) for Conifer Forest and Deciduous Forest vegetation group map units, and by diameter at root collar (DRC) for Woodland vegetation group map units.

Tree Size DBH or DRC Class (in)	Code
0 – 4.9”	TS1
5 – 11.9”	TS2
12 – 19.9”	TS3
≥ 20”	TS4

Table 2: Designated woodland species measured by diameter at root collar (DRC).

Symbol	Scientific Name	Common Name
JUOS	*Juniperus osteosperma*	Utah juniper
JUSC2	*Juniperus scopulorum*	Rocky Mountain juniper
PIMO	*Pinus monophylla*	singleleaf pinyon
ACGR3	*Acer grandidentatum*	bigtooth maple
CELE3	*Cercocarpus ledifolius*	curlleaf mountain mahogany

[4] See Appendix D: Field Reference Data Collection Guide and Protocols

Tree and Shrub Canopy Cover Class

Canopy cover from above represents the total non-overlapping canopy in a delineated area as viewed from above (Nelson et al. 2015). Overlapping canopy not visible from above is not assessed or counted. Map classes representing total tree and total shrub cover from above are listed in **Table 3** and **Table 4**.

Table 3: Map classes for total tree canopy cover as viewed from above.

Tree Cover From Above Class	Code
10 – 29%	TC1
30 – 39%	TC2
40 – 59%	TC3
≥ 60%	TC4

Table 4: Map classes for total shrub canopy cover as viewed from above.

Shrub Cover From Above Class	Code
10 – 14%	SC1
15 – 24%	SC2
25 – 34%	SC3
≥ 35%	SC4

Data Acquisition and Processing

Geospatial Data

Geospatial data acquisition is a major activity in most vegetation mapping efforts that use digital image processing methods. This activity involved assembling remotely sensed images of various spatial and spectral resolutions and an array of geospatial data[5]. A requirement of the mapping process was that any data layer used must be available across the entire SNF to ensure consistency. Data used included imagery from the National Agriculture Imagery Program

[5]See Appendix A: Acquired Geospatial Data for Mapping.

(NAIP), topographic data in the form of Digital Elevation Models (DEMs), burn severity information from the Monitoring Trends in Burn Severity (MTBS) program, surface climate conditions data generated by the Daily Surface Weather and Climatological summaries (Daymet), interferometric synthetic aperture radar (IfSAR) data, and 19 orthorectified Landsat 5 Thematic Mapper satellite images from 2009, 2010, and 2011. In addition, enterprise data such as USFS administrative boundaries, land ownership, roads, trails, hydrology, harvest activities, and land-systems inventory data were provided by the SNF.

Vegetation Plot Data and Photo Interpretation

Vegetation plot data were assembled and aerial photo interpretation was conducted to obtain a reference data set representative of the map units (vegetation type, canopy cover, and tree size class) depicted on the final maps. Reference data are intended to represent a statistically robust sample of broader vegetation conditions across the entire study area. They are used both as training data in model development and to assist with image interpretation. For this project, three types of reference data were used: legacy vegetation plot data, newly collected field reference data, and photo-interpreted data.

Legacy Vegetation Plot Data

Multiple legacy data sources and associated plot information were used for developing dominance type classifications and reference data for vegetation mapping (**Table 5**).

Table 5: Legacy data sources and associated plot information used for vegetation mapping and developing dominance type classifications on the SNF.

Data Set	Dominance Type Classification Plots	Map Reference Plots
Habitat Type Plots		
Steele et al. 1981	260	---
Mauk and Henderson 1984	19	---
Community Type Plots		
Tuhy 1981	534	---
Tuhy and Jensen 1982	90	---
Mueggler 1988	6	---
West et al. 1998	7	---
Idaho Conservation Data Center Plots		
Upland	341	341
Riparian	48	48
Totals	**1,305**	**389**

Additionally, 348 FIA plots comprising 414 conditions were available for this study. These were used in developing the dominance type and the map legend but were not used as reference data for the mapping process. They were used to assess the overall accuracy of the map and to describe the composition of the final vegetation type map units. Over 300 supplemental field plots were also collected in 2014 that will be used to write map unit and dominance type descriptions.

Newly Collected Field Reference Data

Field reference data were collected in 2011 to capture the variation of vegetation composition communities and structure classes across the project area. Data were collected at pre-selected plot locations as well as broader field-selected observation polygon areas. Information gathered included dominant plant species composition, tree and shrub canopy cover, and forest and woodland tree diameter. Dominance type and corresponding vegetation type map unit were determined according to the existing vegetation keys[6]. Percent canopy cover and associated map units were identified using ocular estimation and line intercept methods.

Photo Interpretation

In addition to the field-collected data, aerial photo interpretation was conducted for discernable vegetation composition and structure characteristics to validate and supplement the field-based reference data set. All legacy and newly acquired field reference data were photo-interpreted to validate segment homogeneity and representativeness of the field calls for vegetation type and structure class. Tree canopy cover as viewed from above was estimated for all field sites to attain an interpreted cover class assignment representative of the corresponding segment. Tree cover was also interpreted for an additional set of randomly selected segments across the project area. In addition, supplemental photo interpretation reference sites were acquired for classes not adequately represented in the legacy or newly acquired field sample data sets.

Image and Geospatial Data Processing

Project Area Buffer

For modeling purposes only, the SNF administrative boundary was buffered by 0.25 mile to account for edge effects that can occur along the clipped edge of some topographic and image data sources that may negatively impact the classification models. The buffered area was not included in the final map deliverables. Private lands completely contained within forest were included in the project area to maintain spatial contiguity and are part of the final map deliverables. However, no reference data were gathered within these areas or lands outside the Forest boundary.

All geospatial data, including ancillary GIS layers, remotely sensed images, and topographic layers, were projected to the UTM Zone 11, GRS 1980, NAD83 coordinate system and clipped to the buffered project area.

[6]See Appendix C: Existing Vegetation Keys.

LANDSAT Imagery

All Landsat imagery was co-registered and obstructions (e.g., haze, clouds, cloud shadows) were removed and replaced to develop three seamless seasonal mosaics: spring, summer, and fall. A regression technique was used to replace clouds and cloud shadows and create seamless mosaics between neighboring Landsat scenes. Model II regression is a statistical technique that uses a common area between two images (i.e., overlap between adjacent Landsat scenes) to develop a regression model for each of the spectral bands on the image. The regression equation is then used to “fit” the target image to the reference image by adjusting the pixel values in the non-overlap areas to facilitate the creation of a seamless mosaic between images. Two spectral transformations (Tasseled Cap and Principal Component Analysis) and one spectral index (Normalized Difference Vegetation Index (NDVI)) were produced from the final Landsat mosaics. These derivatives are useful in discriminating between vegetated and non-vegetated as well as among vegetation cover-types.

High Resolution Imagery

The half-meter resource aerial imagery and the 1-meter NAIP imagery were resampled to 10 meters and mosaicked. This step increased the processing efficiency of image segmentation by reducing the resulting segment file size while still maintaining image resolution appropriate for mid-level mapping. An NDVI was produced using the visible and near infrared bands.

Digital Elevation Models (DEMs) and Topographic Derivatives

Topographic derivatives including three slope and aspect based products (slope, slope-aspect (cos), and slope-aspect (sin)), were developed from the 10-meter DEM (Ruefenacht 2014), as well as heatload, surface to ground ratio, trishade, and valleybottom. Such topographic models are used in the modeling process to depict environmental parameters that help predict vegetation cover types.

IfSAR Data

Interferometric synthetic aperture radar (IfSAR) data estimates vegetation height by taking the difference between two radar returns with different wavelengths. One wavelength returns to the sensor after contact with the ground, and the other wavelength returns to the sensor after coming in contact with vegetation. IfSAR difference products were used for the mapping of tree size class, since it correlates with tree height. Unfortunately, IfSAR data is inconsistent across mountainous terrain where steep slopes prevent the radar data from being acquired. Consequently, vegetation height was modeled in areas where IfSAR data was inconsistent.

Other Data

In addition to the image and topographic layers, change detection metrics were developed using the Landsat data record. The Vegetation Change Tracker (VCT) (Huang et al. 2010) algorithm was used to produce these metrics. Landsat 5 TM images from between 1986-2011 were used as inputs to the algorithm. Three different outputs from the VCT algorithm were used in the modeling process. These outputs included rasters that characterized the presence, timing, and magnitude of forest disturbance.

Segmentation

Image segmentation is the process of partitioning digital imagery into spatially cohesive polygonal segments (modeling units) that represent discrete areas or objects on a landscape (Ryherd and Woodcock 1996). The goal of developing segments is to simplify complex images comprised of millions of pixels into more meaningful and mappable objects. Excluding water bodies, the final segments (modeling units) ranged in size from 0.25 to 54 acres with an average size of approximately 3.4 acres.

Modeling units were produced using Trimble eCognition's multi-resolution segmentation algorithm (**Figure 4**). This algorithm is a bottom-up segmentation technique, whereby pixels are recursively merged together based on user-defined heterogeneity thresholds to form discrete image objects. The input data layers used to generate segments included the resampled half-meter imagery (raw bands and NDVI), Landsat imagery (1st principal component) and trishade topographic data. There are four primary parameters within eCognition's multi-resolution segmentation algorithm that control the spatial and spectral quality of the resultant segments: layer weights, scale, shape, and compactness. Layer weights control the relative influence that each of the raster data layers have on the segmentation process[7].

The majority of the influence was given to the half-meter resource photography. While all layers contribute valuable information to the segmentation process, the "texture" of the

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[7] See Appendix E: eCognition Layer Weights.

higher-resolution, multi-spectral data is often most effective at distinguishing between distinct vegetation types and conditions.

Scale is a unit-less parameter that controls the amount of allowable heterogeneity within segments. Scale parameters can range from 1 to infinity, where the low end would delineate polygons only around identical pixels and the high end would result in the entire study area delineated as a single polygon. As such, scale can also be seen as a proxy control for segment size. A high scale parameter means more heterogeneity is allowed within segments and will ultimately result in larger relative segment sizes. Conversely, a small scale parameter means less heterogeneity is allowed within segments, so smaller segments will result. A scale parameter of 16 was used for the SNF segmentation. The appropriate scale factor was determined by experimentation and previous experience with other forests.

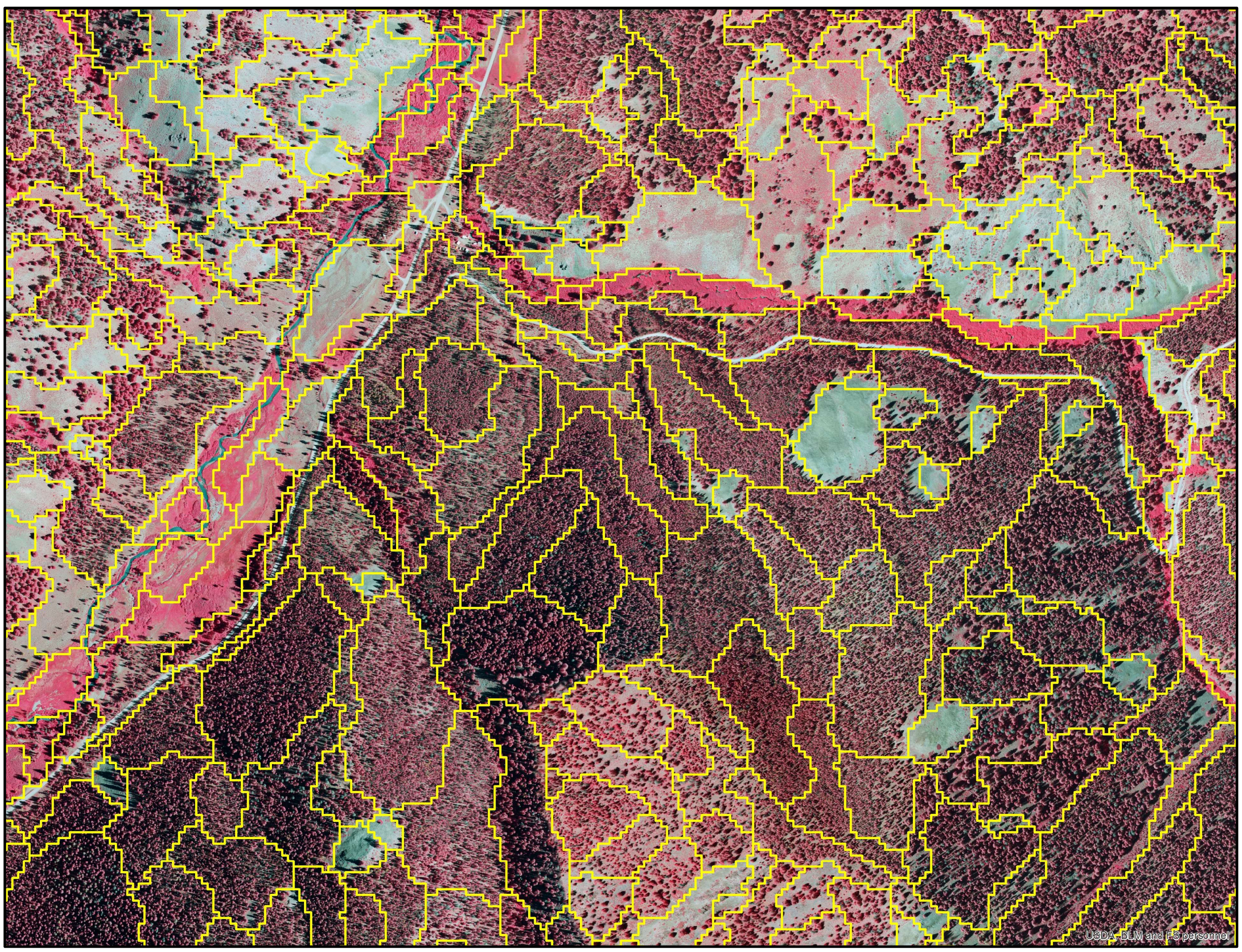

Figure 4: An example of modeling units generated using eCogniton software overlaid on false color half-meter resource imagery.

The shape parameter controls the type of heterogeneity contained within the resultant segments. It is a relative value that caters to the desire for resultant segments to be controlled by spatial homogeneity (shape) and/or spectral homogeneity (color). The values range from 0.0 (a low shape parameter/high color parameter) to 0.9 (a high shape parameter/low color parameter). Segments created with a low shape parameter will have very spectrally homogeneous segments, but less compactness or smoothness of the resultant segments. Conversely, a very high shape parameter will result in segments that have very smooth, compact shapes, but more variance of spectral and topographic pixel values. For the SNF segmentation, a shape parameter of 0.15 was used, which emphasizes spectral and topographic homogeneity over smoothness and compactness of segment shapes.

Similar to the shape parameter, the compactness parameter actually weighs the balance between two opposing spatial qualities: compactness and smoothness. Compactness can be described as the ratio between the area of a given segment and the area of the smallest bounding box of that segment. A very compact segment (e.g., a circular or square segment) will have a ratio that approaches 1, while a segment with low compactness (e.g., an oblong or linear segment) will have a value that approaches 0. Smoothness can be described as the ratio between the length of a segment’s boundary and its area. A very smooth segment will have a short border relative to its area, whereas an irregular segment will have a lengthy border relative to its area. The value of the compactness parameter ranges from 0.0 (low compactness/high smoothness) to 1.0 (high compactness/low smoothness). For the SNF segmentation, a compactness parameter of 0.7 was used, which equally balances the shape and compactness of segments.

In addition to the base parameters described above, RSAC developed additional components to the segmentation rule set, including the definition of a minimum mapping feature (MMF) and associated MMF filtering techniques, and an “object smoothing” process that sends the raw segments through a majority filter-based re-shaping tool that results in smoother, more spatially consistent and functional modeling units.

Reference Data Collection

Field and photo interpretation data were collected to acquire a reference data set with a sufficient number of samples for modeling vegetation type, tree and shrub canopy cover class, and tree size class. This section describes the methods used for collecting new field data and the photo interpretation procedures for obtaining new supplemental sites, tree canopy cover estimates, and assessing reference site homogeneity and representativeness.

Field Data Sample Design and Stratification

Approximately 1,000 reference sites were selected for field visits during the summer of 2011. Multiple criteria were met to maximize site usefulness in the classification models. First, sites were located in relatively homogeneous areas as perceived from high resolution aerial imagery to provide representative samples of vegetation conditions. Second, sites were large enough (one acre or greater) to capture variation in the geospatial data to provide reasonable statistics for a particular sample. Third, sites were placed within 0.25 mile of a road or trail to facilitate accessibility in the field.

In addition to the criteria above, spectral and topographic stratifications were performed to capture the range of conditions anticipated to occur within the project area. A topographic stratification was generated to identify high and low elevation conditions. This binary split was determined through an image interpretation-based review of NAIP imagery by locating distinct changes in vegetation communities due to elevation changes. The topographic split was then further stratified using spectral information. An unsupervised classification was performed using Landsat data by creating clusters of similar spectral qualities in both high and low elevation areas. Sites were then placed within each of these clusters.

Field Data Collection

New plot data collected in the field consisted of dominance type, vegetation type, percent canopy cover, and tree size. A 50-foot radius circular plot was established within the segment as identified on a plot map depicting high resolution aerial imagery and image segments. The plot was placed by field crews at a location estimated to be representative of the vegetation community contained within the segment based on a walk-through of the area. The center of the plot and plot boundary in each cardinal direction from plot center was then marked. Because the map represents an overhead view, all vegetation within the plot area was assessed based on an aerial perspective from above the canopy. Overlapping canopy not visible from above was not assessed or counted as part of the estimates.

Ocular estimates of canopy cover for trees, shrubs, herbaceous and non-vegetated cover types were recorded for the plot totaling 100 percent. Based on these estimates, the vegetation formation for the site was determined using the vegetation key and up to the 5 most abundant species having greater than or equal to 5 percent cover was recorded for that formation. Based on the plot composition and cover estimates, a dominance type and corresponding vegetation group and vegetation type were assigned to the site using the vegetation keys and map unit cross-walk[8].

For forest, woodland, and shrubland sites, total life form canopy cover was estimated to assign the plot to a tree or shrub canopy cover map unit. Upland forest and woodland sites were assigned to a tree canopy cover map unit (**Table 4**). Shrub and riparian woody sites were assigned a shrub canopy cover map unit (

[8] See Appendix C: Existing Vegetation Keys.

Table 5). In addition to the ocular cover estimates, a transect intercept method was used at regular intervals for shrub plots to calibrate ocular estimates.

For forest and woodland sites, the percent visible cover from above of each tree size class was ocularly estimated by species and then totaled for each size class. Tree size was determined using DBH for all tree species except for woodland tree species (**Table 2**). Tree size for woodland tree species was determined using DRC. The tree size class having the most abundant total canopy cover was used for assigning the forested plot to a tree size map unit.

For each plot established by field crews, three to four field observation sites were collected to quickly acquire additional vegetation information within the extended vicinity of the field plot. The plot maps depicting high resolution aerial imagery and image segments were used to identify observation polygons (segments) representing homogenous vegetation. Once a segment from the plot map was identified in the field, dominance type, vegetation type and group, canopy cover class, and tree size class were estimated for the segment. A variety of vegetation types and structure classes were targeted to capture the representative vegetation communities occurring within the project area. Additional information regarding field sampling procedures is discussed in the Field Reference Data Collection Guide[9].

Legacy Field Sites

Nearly 400 legacy field sites, collected for other vegetation studies in 1972 through 2006, were provided to RSAC with GPS coordinates. These data underwent a rigorous QA/QC process in which RSAC eliminated 185 data points that were deemed outdated/inaccurate or occurred in non-homogenous segments. A total of 211 plots from this data set were used as reference sites.

Photo Interpretation

Aerial photo interpretation was conducted using an integrated approach combining field experience and field-sampled data to characterize vegetation composition and structure from digital high resolution resource aerial imagery. The photo interpretation process provided an efficient and cost-effective means to supplement and validate the legacy and newly collected field-based data.

[9] See Appendix D: Field Reference Data Collection Guide and Protocols

Supplemental Sites

To supplement the field-based reference data, photo interpretation was used to acquire additional sites for discernable vegetation types that were not adequately represented in the field sampled data sets. Forest resource specialists provided input on known general locations of vegetation types targeted for photo interpretation. In addition, reference data collected by crews in the field during the previous field season were used to familiarize interpreters with image characteristics of known vegetation types in order to guide interpretation.

Tree Canopy Cover Estimates

To ensure consistent tree canopy cover estimates, all forest and woodland field sites were photo interpreted, and in some instances a new canopy cover label was assigned. Tree canopy cover was evaluated across the full extent of the modeling unit (segment) using high resolution imagery. Example segments, in which the canopy cover labels were established by multiple interpreters, were also used to help calibrate individual interpretation. An additional 1,300 randomly selected tree segments were also photo-interpreted for canopy cover. These supplemental sites increased the data sample size and provided information for remote or inaccessible locations. All sites were reviewed by two photo-interpreters to provide an impartial assessment.

Homogeneity and Representativeness

Photo interpretation was used to assess segment homogeneity and representativeness of the field training reference sites. Homogeneity interpretations involved identifying whether each segment containing a field reference site represented a homogenous vegetation formation. The representativeness of the field training reference site was determined by identifying whether the field-assigned attribute for vegetation group, vegetation type, and tree size class reasonably represented the majority of the segment. Together with the photo interpretation for homogeneity of the segment, the representativeness interpretation allowed for assessing the suitability of each field site attribute for appropriate use as training reference data in the modeling process.

Modeling

Modeling was the step in the mapping process that developed the statistical relationships between the reference data and the geospatial data. These statistical relationships were then applied to building a map. Each model output was carefully evaluated. To improve the model results, reference data were reevaluated, changes or additions were made, and an updated model was developed. This modeling procedure was repeated until the maps were considered satisfactory.

An important task in the modeling process was the development of draft maps to share with SNF resource specialists. This step allowed resource specialists to take maps into the field for verification, apply local knowledge, and make suggestions for improvements to the map products. This feedback allowed modelers to make map changes and improvements prior to final map delivery.

Vegetation Type Map

Vegetation types were mapped using a hierarchical approach. A mapping hierarchy determined the sequence in which models were run, and incorporated the vegetation types most difficult to separate (**Figure 5**). Broad life form types, such as tree and non-tree, were mapped first. These communities were subsequently divided into more distinct categories until the final vegetation types were mapped. There are several advantages to using this hierarchical approach. It enables a targeted review of maps at each level where conspicuous errors can be addressed at the upper levels of the hierarchy, and it provides additional reference sites for mapping the broad classes.

The mapping hierarchy was developed using a data clustering technique based on the relative separability of each vegetation type. Separability was determined by how well the spectral and ancillary data could distinguish between vegetation types. It is quantified by a value known as "entropy," which measures how well a model could be expected to separate vegetation types beyond random chance. Vegetation types with low entropy values are expected to be modeled poorly and vegetation types with high entropy values are expected to be modeled well. The mapping hierarchy was built from the bottom up by identifying and aggregating the least separable classes first.

A Random Forests model (Breiman 2001) was developed for each level of the mapping hierarchy, and the resulting output map was carefully evaluated. To correct inconsistencies, reference data were reevaluated, changes or additions were made, and an updated model was developed. This modeling procedure was repeated until the maps were considered satisfactory.

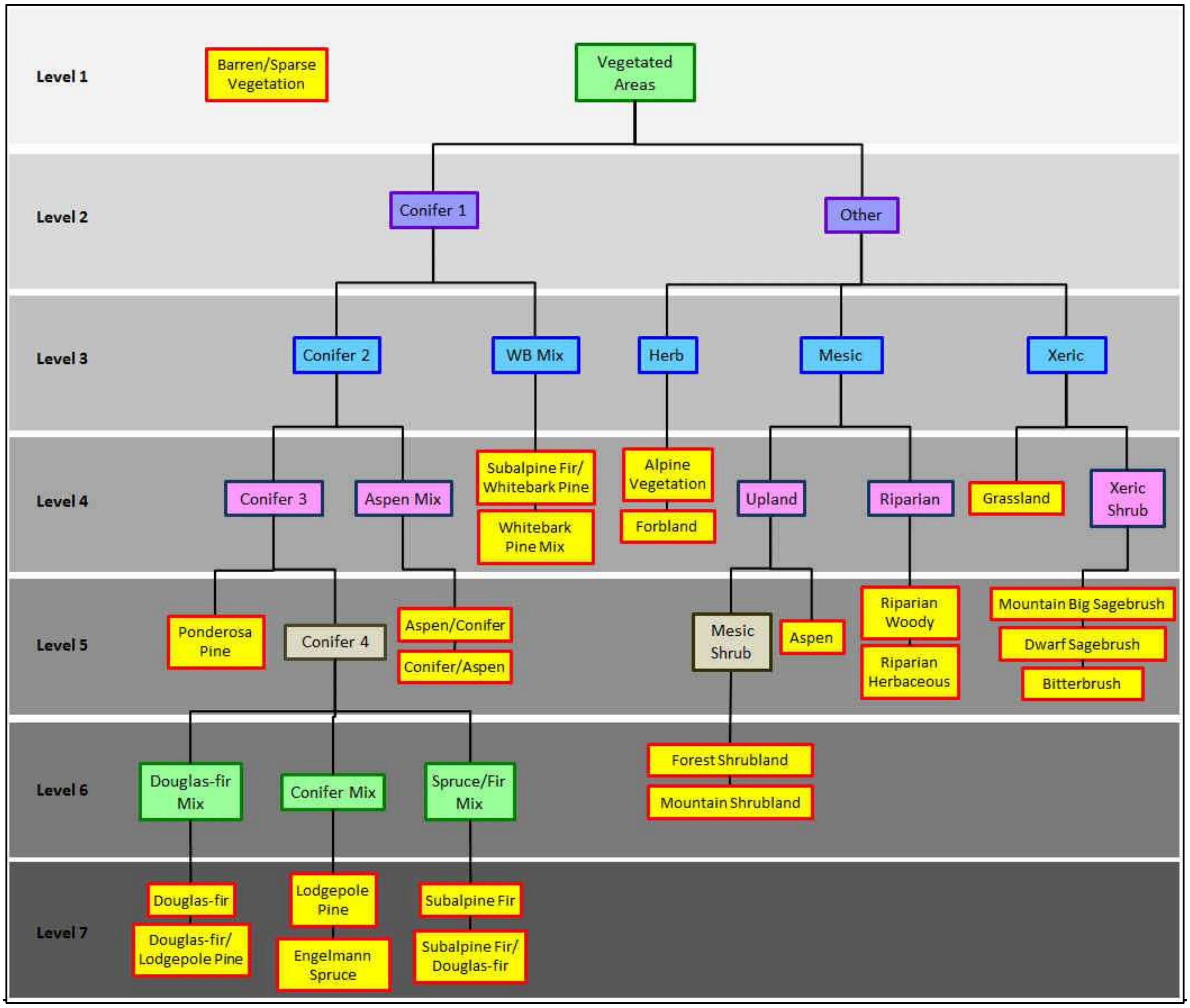

Figure 5: Vegetation type mapping hierarchy example used in the modeling process for the northern ranger districts of the Sawtooth National Forest (Sawtooth National Recreation Area, Ketchum and Fairfield). Successive models were developed starting with level 1 (broad separation of land cover) and progressing to higher levels (more refined). At each level a separate map was developed and reviewed for accuracy.

Canopy Cover Map

Canopy cover was assigned to forest, woodland, and shrubland modeling units identified on the vegetation type map. Forest and woodland canopy cover was determined using photo-interpretation techniques, while shrubland canopy cover was assessed in the field.

To optimize modeling effectiveness, vegetation types were sorted into three canopy groups based on vegetation similarities (**Table 6**). Some groups contained multiple vegetation types while others contained a single type.

A Random Forests model was developed for each canopy group. The output was a continuous canopy cover map. These maps were evaluated using the high resolution imagery and additional reference sites were added if necessary. The continuous maps were assigned canopy cover map units and the individual group maps were combined to produce the final canopy cover map.

Table 6: Canopy cover groups used for modeling canopy cover.

Canopy Cover Group	Vegetation Type
Tree	Aspen, Aspen/Conifer, Conifer/Aspen, Douglas-fir, Douglas-fir/Lodgepole Pine, Engelmann Spruce, Lodgepole Pine, Ponderosa Pine, Subalpine Fir, Subalpine Fir/Douglas-fir, Subalpine Fir/Whitebark Pine, Whitebark Pine Mix, Mountain Mahogany, Pinyon-Juniper, Juniper Mix
Shrubland	Bitterbrush, Dwarf Sagebrush, Mountain Big Sagebrush, Wyoming Big Sagebrush, Forest Shrubland, Mountain Shrubland
Riparian	Riparian Woody

Tree Size Map

Tree size was assigned to modeling units identified as forest or woodland vegetation types. These types were sorted into two groups based on the similarity of vegetation types and the tree size measurements (**Table 7**). Tree size was then modeled independently for each group. Time series analysis layers and derived Landsat imagery that characterizes forest disturbance and/or recovery were used in addition to the customary geospatial predictors[10]. The individual group maps were combined to produce the final tree size map.

[10] See Appendix F: Tree Size Class Modeling Data Layers.

Table 7: Tree groups and the associated vegetation types used for tree size mapping.

Tree Size Groups	Vegetation Type
Forest	Aspen, Aspen/Conifer, Conifer/Aspen, Douglas-fir, Douglas-fir/Lodgepole Pine, Engelmann Spruce, Lodgepole Pine, Ponderosa Pine, Subalpine Fir, Subalpine Fir/Douglas-fir, Subalpine Fir/Whitebark Pine, Whitebark Pine Mix
Woodland	Mountain Mahogany, Pinyon-Juniper, Juniper Mix

Draft Map Review and Revision

The vegetation type draft map was provided to local forest resource specialists for comment and review. Meetings were held in Twin Falls, Idaho, where the review process and associated materials were presented to the Forest staff and other parties[11]. Digital maps using Webmap services were the primary review device. This was an opportunity for local experts to assess the map and give additional information to make improvements.

All the draft map review comments were compiled and reviewed by the vegetation mapping team, and the recommended changes were used to produce the final vegetation type map.

Final Map Development

Three final map products were produced for delivery: 1) vegetation type; 2) canopy cover class for trees and shrubs; and 3) tree size class. For the vegetation type map, segments were first dissolved to merge adjacent polygons of the same type. To achieve the minimum map feature (MMF) of 5 acres, with the exception of aspen, aspen/conifer, conifer/aspen, riparian woody, and riparian herbaceous (2 acre MMF), segments below these thresholds were merged based on a set of rules developed by the RO and SNF staffs[12]. The rules followed logic based on similarities between adjacent polygons, so that neighbors were merged with the most similar type of vegetation. An example of this dissolving and filtering process is shown in **Figure 6**. For the canopy cover and tree size maps, segments were dissolved and merged using a similar

[11] See Appendix G: Draft Map Review

[12] See Appendix H: Merge Rules for Segments Less Than MMF Size.

process. For example, the first choice for filtering out a small TS1 map feature was to merge it with a neighboring TS2 map feature, since that is the most similar class.

The final vegetation type, canopy cover, and tree size maps were edge-matched with the adjacent Boise and Salmon-Challis NFs mid-level existing vegetation maps. This process introduced some map features along the forest boundary that were less than the MMF.

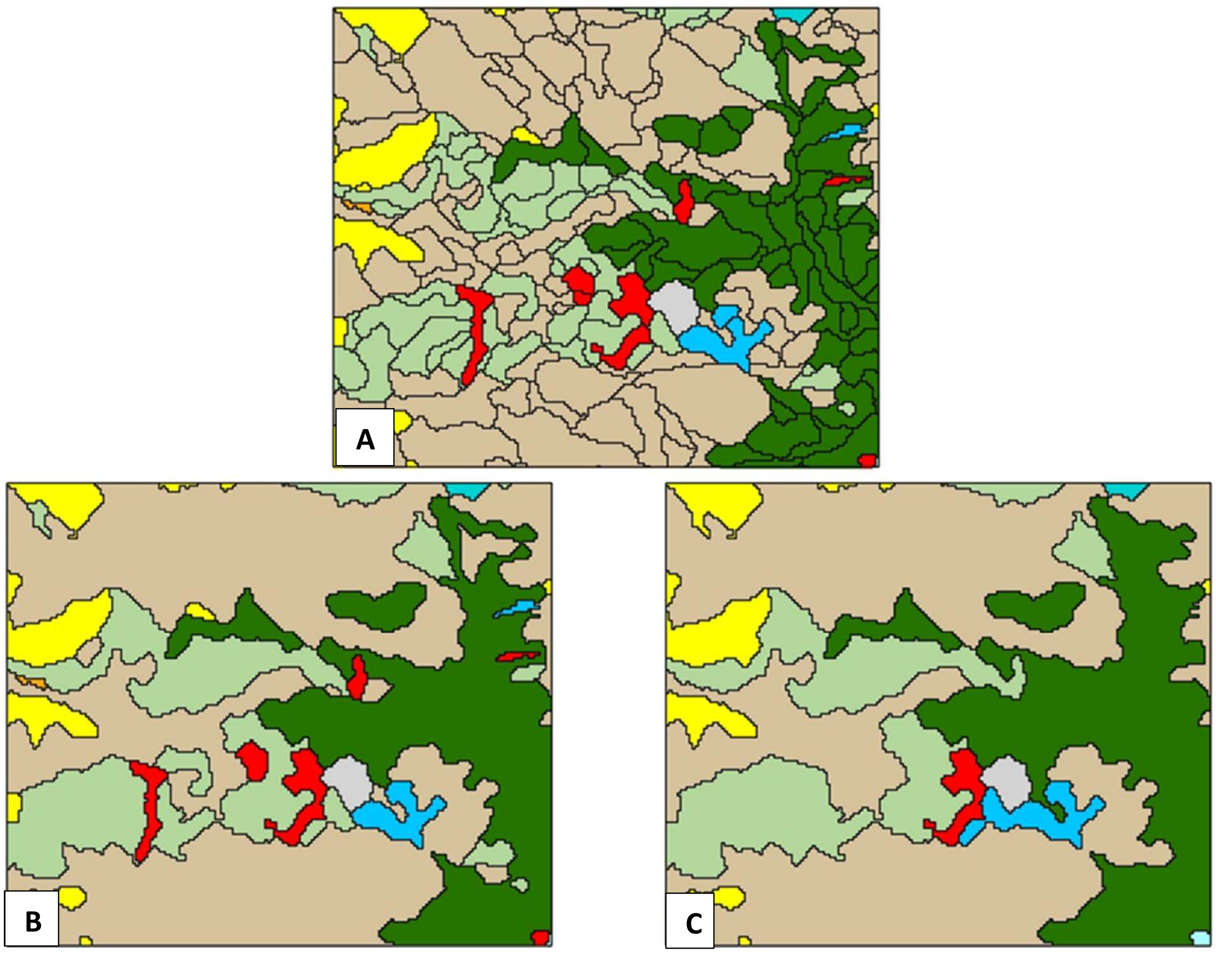

Figure 6: An example of the dissolving/merging and filtering process that was performed on the final maps. Image A shows the original vegetation type map with no dissolving or filtering. Image B illustrates the dissolving and merging of adjacent map features labeled with the same vegetation type. Image C illustrates the filtering process. Segments smaller than the designated minimum map feature size were merged with similar adjacent map features based on the filtering rule-set.

Map Products

The final map products provide for continuous land cover, vegetation type, tree size, and canopy cover information for the entire SNF. The final maps were formatted as a digital geodatabase, which is compatible with Forest Service corporate GIS software. Categories included: Vegetation Group and Vegetation Type, Canopy Cover Class, and Tree Size Class. The vegetation map is consistent with mid-level mapping standards set forth in the Existing Vegetation Classification, Mapping, and Inventory Technical Guide (Nelson et al. 2015). These minimum map feature standards were also maintained in the canopy cover and size class maps.

All mapped areas in the subsequent tables are based upon acreage values calculated in the Region 4 Albers Equal Area projection and the version of Automated Lands Project (ALP) Forest Service ownership that is currently archived in the project record. For area comparison purposes, the use of Region 4 Albers Equal Area projection was preferred over a UTM projection due to its more accurate representation of acreage values across the entire geographic area of Region 4. Changes in the ALP data set or using area calculations from other spatial references will result in variations of total acreages. Total values for many of these tables may not add up correctly due to rounding of their corresponding input values.

Vegetation Type and Group

A total of 30 vegetation types comprising eight generalized groups were mapped (**Table 8**). These classes ranged from specific vegetation species (e.g., Lodgepole Pine) to vegetation communities (e.g., Mountain Shrubland) and more general land use types (e.g., Developed).

Table 8: Total acres and percent area of Vegetation Types by Vegetation Groups. Only National Forest System lands were included in the acreage calculations.

Vegetation Type	Area (ac)	% Area
Alpine		
Alpine Vegetation	21,803	1.0
Conifer Forest		
Douglas-fir	419,279	19.9
Douglas-fir/Lodgepole Pine	17,265	0.8
Engelmann Spruce	12,059	0.6
Lodgepole Pine	117,505	5.6
Ponderosa Pine	7,046	0.3
Subalpine Fir	134,021	6.4
Subalpine Fir/Douglas-fir	39,275	1.9
Subalpine Fir/Whitebark Pine	86,083	4.1
Whitebark Pine Mix	58,320	2.8
Deciduous Forest		
Aspen	54,263	2.6
Aspen/Conifer	32,599	1.5
Conifer/Aspen	18,687	0.9
Herbland		
Forbland	22,059	1.1
Grassland	85,465	4.1
Non-Vegetated/Sparse Vegetation		
Agriculture	484	0.0
Barren/Sparse Vegetation	148,539	7.0
Developed	793	0.0
Water	8,506	0.4
Riparian		
Riparian Herbaceous	5,039	0.2
Riparian Woody	16,073	0.8
Shrubland		
Bitterbrush	11,843	0.6
Dwarf Sagebrush	56,561	2.7
Forest Shrubland	58,972	2.8
Mountain Big Sagebrush	492,820	23.4
Mountain Shrubland	99,966	4.7
Wyoming Big Sagebrush	20,600	1.0
Woodland		
Juniper Mix	47,535	2.3
Mountain Mahogany	8,186	0.4
Pinyon-Juniper	8,740	0.4
Total	**2,110,385**	**100.0**

Tree and Shrub Canopy Cover

A canopy cover map was generated by independently processing forest, woodland and shrubland canopy cover (**Table 9)**. All other areas were mapped as having no canopy cover. Canopy cover categories were assembled into a wall-to-wall map for the entire SNF.

Table 9: Total acres and percent area for each tree and shrub canopy cover class. Only National Forest System lands were included in the acreage calculations.

Tree Canopy Cover Class	Area (ac)	% Area
TC1 (10 - 29%)	499,690	47.1
TC2 (30 - 39%)	300,952	28.4
TC3 (40 - 59%)	195,226	18.4
TC4 (≥ 60%)	64,994	6.1
Total	**1,060,862**	**100.0**

Shrub Canopy Cover Class	Area (ac)	% Area
SC1 (10 - 14%)	98,835	13.1
SC2 (15 - 24%)	141,660	18.7
SC3 (25 - 34%)	195,137	25.8
SC4 (≥ 35%)	321,203	42.4
Total	**756,835**	**100.0**

Tree Size

A tree size map was generated for all areas identified as forest or woodland in the existing vegetation map. These lands were classified into one of four tree size classes (**Table 10**). All other areas were mapped as having no size class. The tree size class map was assembled into a complete coverage for each mapping region and mosaicked for the entire SNF.

Table 10: Total acres and percent area for each tree size class. Only National Forest System lands were included in the acreage calculations.

Tree Size DBH or DRC Class (in)	Area (ac)	% Area
NF (Nonforest)	1,049,523	49.7
TS1 (0 - 4.9")	1,742	0.1
TS2 (5 - 11.9")	499,392	23.7
TS3 (12 - 19.9")	361,937	17.2
TS4 (≥ 20")	197,792	9.4
Total	**2,110,385**	**100.0**

Accuracy Assessment

An accuracy assessment for a mapped product can be defined as a statistical summary or metric, usually presented as a table, comparing the mapped classes to reference data or "truth." An accuracy assessment should provide objective information on the quality or reliability of the map, and can be used to determine the utility of the map and its associated risks with respect to specific applications (Nelson et al. 2015). Thus, it is important that the reference information used to conduct accuracy assessments be independent from the information used to produce the map and also be a reliable and unbiased source for representation of ground conditions.

Quantitative inventory data were used for the accuracy assessment on the SNF. This included the most current FIA, base-level, field-collected data available for each plot; consisting of a spatially complete systematic hex-grid sample for all forest and nonforest lands. This source data set spanned a full cycle of ten years (2005-2014) of FIA annual inventory plots on the SNF. Systematic inventory plots provide a spatially balanced estimate of map unit (e.g., vegetation type, canopy cover class, and tree size class) proportions for a population. Below are more detailed discussions concerning: 1) the use of reference datasets for accuracy assessments, 2) the use of the map product from the accuracy assessment perspective, and 3) the accuracy assessment design.

Use of Reference Data Sets for Accuracy Assessments

Reference data is quantitative or qualitative information about ground features necessary to successfully complete a map accuracy assessment. Although the collection of field reference data is not required, some type of reference data is needed to help interpret and/or assess accuracy during a mapping project. Quantitative accuracy assessments usually depend on the collection of reference data, which is assumed to be known information of high accuracy (Brewer et al. 2005).

There is rarely a sufficient sample size to quantify all vegetation types occurring across a geographic area. Important types of naturally small extent, such as riparian communities, are rarely sampled by a systematic or random design. Inventory data, therefore, involves trade-offs between resolution and reliability. It is often necessary to generalize or aggregate vegetation types and/or structural classes in order to achieve the sample sizes needed to provide statistically reliable estimates of the amounts of those types or classes (Brewer et al. 2005).

When data collection protocols for accuracy assessment samples are similar to those of the training samples, then assigning the appropriate map unit label to an accuracy assessment sample is straightforward. If plot designs are dissimilar, then developing a crosswalk and reinterpreting or verifying plot information using high-resolution imagery, or conducting field visits may be necessary. When existing data, such as FIA data, is used to assess map accuracy, consideration should be given to address differences in data collection methods (Stehman and Czaplewski 1998). The following are some limitations that need to be considered when using FIA or other data not explicitly designed for accuracy assessments:

- Size of FIA plot vs. unit of evaluation for the map
- Nature of FIA condition boundaries vs. mapped polygon boundaries
- Vintage of field collected data of annual cycle vs. vintage of imagery
- Insufficient numbers of accuracy assessment sites for less common classes

One consideration when using FIA data is that it is typically collected on a 10-year cycle by the Interior West FIA (IWFIA) unit, such that one-tenth of each state is sampled each year. As a result, the average measurement period for a 10-year cycle of plot data would be about five years old (such as that for the SNF). An analyst must determine how well the remotely-sensed data used for modeling, which may have been taken during one or more years, will coincide temporally with ten years' worth of measurement dates for the plot data. Such differences may cause additional accuracy errors if there were significant disturbances in vegetation types or cover during that time.

Although the use of FIA data as a reference data set for accuracy assessments has its limitations, it also has many advantages. FIA data are a statistically robust, spatially distributed, unbiased sample that is updated annually over a 10-year cycle. It has well-established and consistent data collection protocols that facilitate multi-temporal comparability and long-term usage. FIA data are also readily available to users.

FIA data can be used early in the classification scoping process to identify or distinguish rare (less than 1 percent of area on a Forest), uncommon (1 to 10 percent), and common (greater than 10 percent) classes. Rare classes are typically too spatially-limited for normal mid-level mapping processes, and may need to be "burned in" (incorporated) later using local knowledge from Forest Service employees. This process can help make the mapping process more efficient by reducing the number of initial classes and/or the number of classes that may need further collapsing following an accuracy assessment based on too few samples. Other sources of reference information are often needed (e.g., intensified, stratified, or photo-interpreted data) for less common classes.

Use of Map Products

Map features (e.g., polygons) rarely have homogenous characteristics; instead, they usually contain varying proportions of vegetation, structure, and cover class mixtures. Therefore, map products should be used within the context of the map unit and the associated dominance type descriptions.

The map assessment may identify map units with low accuracy. These map units may meet the desired thematic detail but not the desired thematic accuracy. By assessing the error structure relative to the mapping objectives and management questions, map units can be combined into new, more generalized map units that better meet accuracy requirements. Merging map units is not an edit or a correction to the final map; rather, this process is a generalization of the map legend to achieve an acceptable compromise between thematic detail and classification accuracy (Nelson et al. 2015).

Accuracy Assessment Design

The three basic components of an accuracy assessment are: sample design, response design, and the analysis protocol (Stehman and Czaplewski 1998). The sample design determines the plot design and the distribution of sites across the landscape. The response design determines how the sites are labeled or assigned to map units. The analysis protocol summarizes the results of information obtained from the sampling and response designs.

Sample design and sample size (number of samples) are important considerations for an efficient accuracy assessment. The *sample design* should be statistically and scientifically valid. The sampling unit (i.e., polygon or point) should be identified early in the process since it affects much of the plot design. While training data used for producing a map may be collected according to a preferential or representative sampling scheme (purposive sampling), data used for an accuracy assessment should be collected using an unbiased approach where samples have a known probability of selection (Stehman and Czaplewski 1998). The number of sample sites should be large enough to be statistically sound but not larger than necessary for the sake of efficiency. The need for statistical validity is often balanced with practical considerations, such as time and budget constraints (Nelson et al. 2015).

The *response design* includes procedures for collecting the accuracy assessment samples and protocols for assigning a map unit label to each accuracy assessment sample (Stehman and Czaplewski 1998). If an existing data set is used, then the information needs to be deemed sufficient for assigning a map unit label. Additional information or interpretations may be needed as well.

The *analysis protocol* summarizes the results of information obtained from the sampling and response designs (Stehman and Czaplewski 1998). A primary objective of an accuracy assessment is to quantify the level of agreement between mapped and observed attributes. This is most often performed for classified (categorical) maps by creating an error matrix, and deriving the accuracies from that matrix. The error matrix is the standard way of presenting results of an accuracy assessment (Story and Congalton 1986). This matrix is a cross-tabulation table (array) that shows the number of reference sites found in every combination of reference data category and map unit category. Agreement can also be measured by comparing the similarity of the mapped and observed proportions of the attributes within the mapped area.

Quantitative Inventory

Quantitative vegetation inventory consists of applying an objective set of sampling methods to quantify the amount, composition, condition, and/or productivity of vegetation within specified limits of statistical precision. To be most useful, a quantitative inventory must have a statistically valid sample design, use unbiased sampling methods, and provide both population and reliability estimates (Brewer et al. 2005).

Phase 2 FIA Base-level Inventory

The FIA program of the USDA Forest Service has been in continuous operation since 1930. Their mission is to conduct and continuously update a comprehensive inventory and analysis of the present and prospective conditions of the renewable resources of the forests and rangelands of the United States. This national program consists of four regional FIA units. The IWFIA unit, part of the Rocky Mountain Research Station, conducts inventories throughout National Forest System Regions 1, 2, 3 and 4.

Forest Lands

Although FIA's mission includes rangeland assessments, it was only funded to conduct forest land inventories. The Phase 2 forest inventory consists of permanently establishing field sampled plots distributed across each state with a sample intensity of about one plot per 6,000 acres. Field data are typically collected only on plot locations where forest land is present. In general, forest land has at least 10 percent canopy cover of live tally tree species of any size or has had at least 10 percent canopy cover of live tally species in the past; based on the presence of stumps, snags, or other evidence. Each plot consists of a cluster of four subplots that fall within a 144-foot radius circle based on the plot center spread out over approximately 1.5 acres. Most Phase 2 data are related to tree and understory vegetation components of the forest. Plots are distributed across all ownerships throughout the United States; therefore, there are a number of plots in proportion to the extent of a vegetation type on the landscape. For more details on the national FIA program visit http://www.fia.fs.fed.us/ or for the IWFIA program at http://www.fs.fed.us/rm/ogden/.

All Condition Inventory

The USFS Intermountain Region (Region 4) has entered into an agreement with IWFIA to conduct an "All Condition Inventory" (ACI) on Region 4 National Forest System (NFS) lands, which is a base-level, quantitative inventory that collects similar vegetation information on both forest and nonforest conditions throughout the Region. ACI was initiated as a joint effort by FIA and the USFS Northern Region (Region 1), in which the protocol was adapted and expanded to meet Region 4 needs. As an extension of the grid-based forest land inventories that IWFIA conducts on all ownerships throughout the Interior West states; ACI will result in a consistent and unbiased wall-to-wall inventory on all Region 4 NFS forest and nonforest lands. A nonforest condition includes all lands not considered a forest condition by FIA's definition of forested lands. Thus, the Northern and Intermountain Regions have collaborated with IWFIA to conduct a seamless inventory with the same data collection protocols on all NFS lands regardless of the presence or absence of tree cover.

Methods

In general, quantitative inventory data from FIA plots can be used for many assessments or as complementary information for other projects. Mid-level vegetation mapping typically produces three layers of information: dominance type, canopy cover, and tree size. Since the inventory data are a true sample (systematic and random) of these characteristics across the landscape (i.e., a national forest, county, or state), the data can be used in ways that complement the mapping process, as an independent data set to assess the accuracy of the maps, or both. For mid-level mapping purposes, there are several ways in which the inventory data can be used:

1. Understanding the proportional distributions of forest dominance types and tree sizes across a map project area for map unit design and intermediate map evaluation purposes

2. Designed-based (e.g., FIA plots) vs. model-based area estimate comparisons of the final map products (non-site-specific)
3. Site-specific accuracy assessment

Discussed below are the methods used for data preparation and classification, non-site-specific area estimate comparison, and site-specific accuracy assessment for this project using FIA base-level plot data. The set of FIA base-level plots used for this accuracy assessment are referred to in the subsequent accuracy assessment subsections of this report as "inventory" plots.

Data Preparation and Classification

The first step in the data preparation process was acquiring data. Before classification began, it was necessary to query data from IWFIA's regional database, join the proper tables, and calculate variables used in this process. Quality control checks were run on previously populated and vetted statewide national databases to assure that plot-level and condition-level estimates (e.g., live basal area per acre estimates, understory vegetation species, and lifeform cover estimates) were correct.

The next step was assigning dominance types to the plot/condition-level data (some plots have multiple conditions) in conjunction with the classification criteria outlined in the SNF Existing Vegetation Keys[13]. This complicated step involved separating plots and their plot conditions into many categories in order to use the appropriate available information for a particular condition's characteristics. The FIA plot layout and an example scenario where more than one condition exists on a plot are illustrated in Appendix I[14].

Species-level canopy cover data were available for all lifeforms except trees. A variable collected on all plots "total live crown cover for all tree species" was used to determine necessary thresholds for forest and woodland dominance types. Basal area (BA) by species was used to calculate total crown cover by tree species, and then used within the key.

The following lists summarize the primary steps involved in assigning vegetation dominance types, tree size, and crown cover.

Vegetation dominance type steps included:

- Calculate live BA per acre estimates by species

[13] See Appendix C: Existing Vegetation Keys.
[14] See Appendix I: Diagram of an FIA Plot

- Convert to percentages of total live BA by species
- Identify species with plurality of percent live BA
- Use live BA percentages as a surrogate in key for identifying species that are the most abundant in terms of relative cover
- Where necessary in key, use total cover to convert to absolute cover
- Determine general plot vegetation characteristics based upon vegetation groups and allocate into classes
- Based on plot and plot/condition information, assign the appropriate dominance type, vegetation type, and vegetation group according to key for each plot/condition
- Determine if plot data are relevant due to potential disturbance since plot measurement. If they are not relevant, determine another method of assigning dominance type information (imagery, plot photos, notes, etc.) so that plot information is current with map information

Tree Size steps included:

- Calculate live BA per acre estimates by diameter class by condition
- Convert to percentages of total live BA by diameter class by species
- Identify diameter class with plurality of percent live BA
- Assign diameter classes to plot/conditions
- Determine if plot data are relevant due to potential disturbance since plot measurement. If they are not relevant, determine another method of assigning tree size information (imagery, plot photos, notes, etc.) so that plot information is current with map information

Canopy cover steps included:

- Use total live tree cover (greater than 10 percent) variable to determine forest and woodland conditions
- If total live tree cover is less than 10 percent, then use understory vegetation cover estimates by lifeform and species to determine nonforest cover classes
- Determine if plot data are relevant due to potential disturbance since plot measurement. If they are not relevant, determine another method of assigning crown or shrub cover information (imagery, plot photos, notes, etc.) so that plot information is current with map information

Non-Site-Specific Accuracy Assessment

A non-spatial comparison of design-based (inventory) vs. model-based (mapped) area outputs is one approach of assessing a final map. Such a comparison was, in-part, the reason that the Forest Service management decision appeal was affirmed in the Mission Brush Case (Lands Council vs. McNair 2008). Designed-based estimates such as those obtained by using FIA plot data provide an excellent source of accuracy assessment information since it is a true systematic random sample.

Stratification for Area Estimates

Area expansion factors are generated for each inventory plot/condition, which signifies the area that an inventory plot represents at the population level. The stratification process is an important step in determining area estimates from inventory data as it provides an area representation from which area expansions can be determined. A stratification crosswalk was used for the SNF to classify plots into generalized categories based upon their map-assigned strata (**Table 11**). Vegetation groups were classed into one of 10 strata, based upon their vegetation characteristics. Some vegetation groups with relatively large acreages were given their own strata layer, which typically assists in the inventory estimation process.

These data were considered a legitimate, unbiased sample because the inventory plots were spatially-distributed, unbiased estimates, and all data collection protocols were consistent (whether forest or nonforest). There were a total of 338 plot/conditions used for the area estimation from a total of 306 inventory plot locations. As part of the plot data collection protocol, conditions are mapped and sampled separately for each plot because they are considered an area of relatively uniform ground cover (i.e., homogenous vegetation cover), which allows area weights to be assigned using condition proportions. Based upon the area of the strata and the distribution of plots, an area expansion factor was applied to each plot/condition based upon the strata value.

Table 11: Inventory plots were grouped into generalized strata using their vegetation map unit and the following crosswalk. These general strata classifications help inform the inventory estimation process by assigning plots to strata. The Agriculture and Developed map units were omitted from this table because they had zero acres.

STRATA	Vegetation Map Unit	Acres
sage_mix	Mountain Big Sagebrush	484,524
	Dwarf Sagebrush	71,965
	Wyoming Big Sagebrush	13,491
douglas-fir_mix	Douglas-fir	422,959
	Douglas-fir/Lodgepole Pine	13,584
subalpine fir_mix	Subalpine Fir	144,154
	Subalpine Fir/Whitebark Pine	59,074
	Subalpine Fir/Douglas-fir	56,151
conifer mix	Lodgepole Pine	117,439
	Whitebark Pine Mix	39,698
	Engelmann Spruce	26,465
	Ponderosa Pine	11,327
shrubland_mix	Mountain Shrubland	92,507
	Forest Shrubland	59,299
	Bitterbrush	18,976
barren_sparse_veg	Barren/Sparse Vegetation	142,779
	Water	15,543
herbland_alpine_mix	Grassland	119,155
	Forbland	5,812
	Alpine Vegetation	4,359
aspen_mix	Aspen	48,589
	Aspen/Conifer	38,733
	Conifer/Aspen	18,227
woodland_mix	Juniper Mix	45,123
	Mountain Mahogany	12,892
	Pinyon-Juniper	6,446
riparian_mix	Riparian Herbaceous	14,075
	Riparian Woody	7,037
Total		**2,110,385**

Site-Specific Accuracy Assessment

Another use for a quantitative inventory (e.g., FIA plots) is for conducting site-specific accuracy assessments on existing vegetation mid-level map products. The use of all plots was necessary so that the systematic, unbiased nature of the grid was not compromised. This assessment was completed by comparing the subplot 1 centroid location of an FIA plot[15] to the spatially-coincident location of a mapped polygon feature.

It was determined that to best portray map accuracy, the assessment would be performed on the final map features, and not the intermediate modeled segments, which serve as the building blocks for the final product. This resulted in polygons that were at least the same size but more often larger than assessment segments, which allowed a larger percentage of plots to fit entirely within an evaluation unit; this reduced the number of plots that straddled segments. Consequently, some polygons were relatively large. Due to the inherent differences between the inventory sample design and map characteristics, the inventory sample design (e.g., size of plot), the field data collection protocols, and the defining attributes (forest type, tree size, tree cover density, etc.) associated with inventory vegetation condition boundaries were often not in alignment with the size or characteristics of the mid-level mapped polygon boundaries.

As noted in the "Data Preparation and Classification" section, FIA plot data were evaluated to determine if they were still relevant due to potential disturbances (primarily stand-altering wildfires) since plot measurement occurred, or before plot measurement occurred for fire disturbances after 2011, which was the remotely-sensed imagery date used for modeling the map. First, there were 62 FIA plot/conditions within the burn perimeters of major wildfires within the SNF, occurring from 2005-2014. Of the 62 plot/conditions, 13 needed checking to determine if it was necessary to synchronize disturbance year with plot measurement year and imagery date. Following evaluation of those 13 plot/conditions for changes due to fire disturbance, three plot/conditions were "disturbed" enough by the fires. Consequently, the relevant data (e.g., vegetation type, cover estimates, etc.) for the three plot/conditions were adjusted to reflect those changes, so the remotely-sensed data and plot data were again in sync regarding the fire disturbance.

Prior accuracy assessments used an involved process of analyzing inventory plots against map polygons by applying decision rules regarding the use of plots based upon their location within a polygon and/or near a polygon edge. For the SNF assessment, it was decided to objectively use the subplot center location without any adjustments. This process allows for a more objective and repeatable accuracy assessment.

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[15] See Appendix I: Diagram of an FIA Plot

Results

Non-Site-Specific Accuracy Assessment

Classification and stratification of inventory plot/conditions for generating area estimates was performed, resulting in area estimates for vegetation group, vegetation type, tree size class (forest and woodland), and canopy cover class (tree and shrub). Total values for many of these tables may not add up correctly due to rounding of their corresponding input values.

Area Estimates Based on Inventory Plots

The source data set for this analysis was obtained from approximately ten years (2005 to 2014) of FIA data; including All Condition Inventory (ACI) data, which was gathered to gain a representation of nonforest plots. There were a total of 338 plot/conditions available for area estimation from a total of 306 inventory plot locations. When plots have more than one vegetation condition, condition-level plot data was used for area estimates. While the area classification focused on the condition level data, the site-specific accuracy assessment focused on plot level information and its spatial relationship to the mapped polygons.

Summarized inventory data results for predicted area, percent area, and number of plot/conditions by five map attributes (vegetation group, vegetation type, tree size class, tree canopy cover class, and shrub canopy cover class) are presented in the following sections.

Vegetation Group Area Estimates

Approximately 51 percent of the SNF is in forest and woodland groups, and approximately 49 percent are in nonforest groups. The conifer forest class is the largest group with approximately 44 percent total area. Shrubland is the second largest vegetation group covering 29 percent, and non-vegetated or sparse vegetation covers approximately 8 percent of the area. The SNF had relatively few inventory plot/conditions representing riparian (four) or alpine (five) vegetation groups (**Table 12**).

Table 12: Inventory-estimated area (acres), percentage of total area, and number of FIA plot/conditions listed by both a forest/nonforest category and a vegetation group category for the SNF.

Vegetation Group	Area (ac)	% Total Area	Number of Plot/Conditions
Forest and Woodland			
Conifer Forest	938,087	44.5	164
Deciduous Forest	71,097	3.4	11
Woodland	66,791	3.2	13
Forest and Woodland Total	**1,075,976**	**51.0**	**188**
Nonforest			
Shrubland	626,716	29.7	91
Non-Vegetated/Sparse Vegetation	175,046	8.3	27
Herbland	167,191	7.9	23
Alpine	40,965	1.9	5
Riparian	24,492	1.2	4
Nonforest Total	**1,034,410**	**49.0**	**150**
Total	**2,110,385**	**100.0**	**338**

Vegetation Type Area Estimates

Douglas-fir vegetation type covers the largest area at about 24 percent of the SNF (by acres), followed by Mountain Big Sagebrush (17 percent), Subalpine Fir (9 percent), Non-Vegetated/Sparse Vegetation (8 percent), Mountain Shrubland (6 percent), Grassland (5 percent) and Lodgepole Pine (4 percent). The remaining vegetation types compose three percent or less area. Eighteen vegetation types also had less than ten classified inventory samples each, which reflects the relative scarcity of occurrence of these types across the Forest (**Table 13**).

Table 13: Inventory-estimated area (acres), percentage of total area, and number of plot/conditions by forest/nonforest category and vegetation type on the SNF. Note that in this table, one water plot and its associated acreage was added to the Non-Vegetated/Sparse Vegetation type.

Vegetation Type	Area (ac)	% Total Area	No. of Plot/Conditions
Forest and Woodland			
Douglas-fir	503,818	23.9	85
Subalpine Fir	201,351	9.5	37
Lodgepole Pine	91,929	4.4	16
Juniper Mix	53,899	2.6	10
Aspen	45,583	2.2	7
Engelmann Spruce	34,748	1.6	6
Subalpine Fir/Douglas-fir	32,137	1.5	6
Whitebark Pine Mix	24,692	1.2	6
Subalpine Fir/Whitebark Pine	24,323	1.2	4
Douglas-fir/Lodgepole Pine	20,377	1.0	3
Aspen/Conifer	13,627	0.6	2
Mountain Mahogany	12,892	0.6	3
Conifer/Aspen	11,886	0.6	2
Ponderosa Pine	4,711	0.2	1
Forest and Woodland Total	**1,075,976**	**51.0**	**188**
Nonforest			
Mountain Big Sagebrush	365,886	17.3	53
Non-Vegetated/Sparse Vegetation	175,046	8.3	27
Mountain Shrubland	138,638	6.6	18
Grassland	114,013	5.4	18
Forbland	53,178	2.5	5
Dwarf Sagebrush	46,965	2.2	9
Alpine Vegetation	40,965	1.9	5
Forest Shrubland	33,103	1.6	5
Wyoming Big Sagebrush	21,063	1.0	3
Bitterbrush	21,063	1.0	3
Riparian Woody	17,454	0.8	3
Riparian Herbaceous	7,037	0.3	1
Nonforest Total	**1,034,410**	**49.0**	**150**
Total	**2,110,385**	**100.0**	**338**

Tree Size Class Area Estimates

Tree size class area was estimated for forest and woodland (TS1-TS4) as well as nonforest (NF) classes. Nonforest was the most common class (approximately 49 percent), followed by Tree Size Class 2 (about 22 percent), which represents the 5 - 11.9" diameter class. Tree size classes with five inches or more diameters accounted for approximately 47 percent of the total area (**Table 14**).

Table 14: Inventory-estimated area (acres), percentage of total area, and number of plot/conditions by tree size class for the forest and woodland (TS1-TS4), and nonforest (NF) classes on the SNF.

Tree Size Code	Tree Size Class DBH or DRC (in)	Area (ac)	% Total Area	Number of Plot/Conditions
TS1	0 - 4.9"	74,415	3.5	15
TS2	5 - 11.9"	466,684	22.1	80
TS3	12 - 19.9"	277,461	13.1	47
TS4	≥ 20"	257,415	12.2	46
NF	Nonforest	1,034,410	49.0	150
Total		**2,110,385**	**100.0**	**338**

Canopy Cover Class Area Estimates

Canopy cover area was estimated for both tree and shrubland canopies. The tree cover classes (TC) are primarily dominated by Douglas-fir, Subalpine Fir and Lodgepole Pine vegetation types. The shrubland cover classes (SC) are primarily dominated by Mountain Big Sagebrush, Mountain Shrubland, and Dwarf Sagebrush vegetation types (**Table 13**). The most prevalent cover class was TC3 at 17 percent total area, followed by TC1 (16 percent) and SC4 (11 percent). Tree cover classes make up 51 percent of the total area, while shrubland cover classes encompass almost 30 percent. The primary reason for large representation of areas in the tree cover classes is the prevalence of Douglas-fir (**Table 15**).

Table 15: Inventory-estimated area (acres), percentage of total area, and number of plot/conditions by tree and shrub canopy cover class on the SNF.

Canopy Cover Code	Canopy Cover Class	Area (ac)	% Total Area	Number of Plot/Conditions
TC1	TC 10 - 29%	341,160	16.2	61
TC2	TC 30 - 39%	172,250	8.2	31
TC3	TC 40 - 59%	368,998	17.5	63
TC4	TC ≥ 60%	193,567	9.2	33
SC1	SC 10 - 14%	42,740	2.0	8
SC2	SC 15 - 24%	168,467	8.0	24
SC3	SC 25 - 34%	171,851	8.1	25
SC4	SC ≥ 35%	243,658	11.5	34
Nonforest/Nonshrubland	No Canopy Cover	407,694	19.3	59
Total		**2,110,385**	**100.0**	**338**

Comparisons of Mapped to Inventory Area Estimates

In general, map units with many classes such as vegetation type tend to have more discrepancies between the mapped area estimates and field sampled occurrences. This is probably due to more and finer thresholds hindering recognition of class spectral signatures, and may also be due in part to limitations in the number of accuracy assessment sites available from quantitative inventory plots.

Vegetation Group Comparisons

Summaries were created to compare inventory-derived estimates and mapped area acreages (**Table 16** and **Figure 7)**. The Conifer Forest vegetation group composes more than 40 percent of both map and inventory plot data, followed by the Shrubland group near 30 percent. Agreements between the map and inventory area estimates for most vegetation groups were relatively close. The largest discrepancy between inventory and mapped groups was demonstrated in the Shrubland class (5 percent difference). It appears the only classes with a larger map prediction, compared to their respective inventory estimate (i.e., positive percent difference), were the Shrubland and Deciduous Forest vegetation groups (**Figure 7**). Discussions regarding inventory confidence interval estimates and an error matrix component of this report will further evaluate these acreage differences.

Table 16: Mapped versus inventory-based estimates of area by existing vegetation groups on the SNF. Percent Difference is based on a difference in percentages of total area between mapped and inventory estimates.

Veg Group Code	Vegetation Group Class	Map Acres	Map % of Total Area	Inventory Acres	Inventory % of Total Area	Acreage Difference	% Difference
C	Conifer Forest	890,852	42.2	938,087	44.5	-47,235	-2.2
S	Shrubland	740,762	35.1	626,716	29.7	114,046	5.4
N	Non-Vegetated/ Sparse Vegetation	158,322	7.5	175,046	8.3	-16,724	-0.8
H	Herbland	107,524	5.1	167,191	7.9	-59,667	-2.8
D	Deciduous Forest	105,549	5.0	71,097	3.4	34,452	1.6
W	Woodland	64,461	3.1	66,791	3.2	-2,330	-0.1
A	Alpine	21,803	1.0	40,965	1.9	-19,162	-0.9
R	Riparian	21,112	1.0	24,492	1.2	-3,380	-0.2
Total		**2,110,385**	**100.0**	**2,110,385**	**100.0**	**N/A**	**N/A**

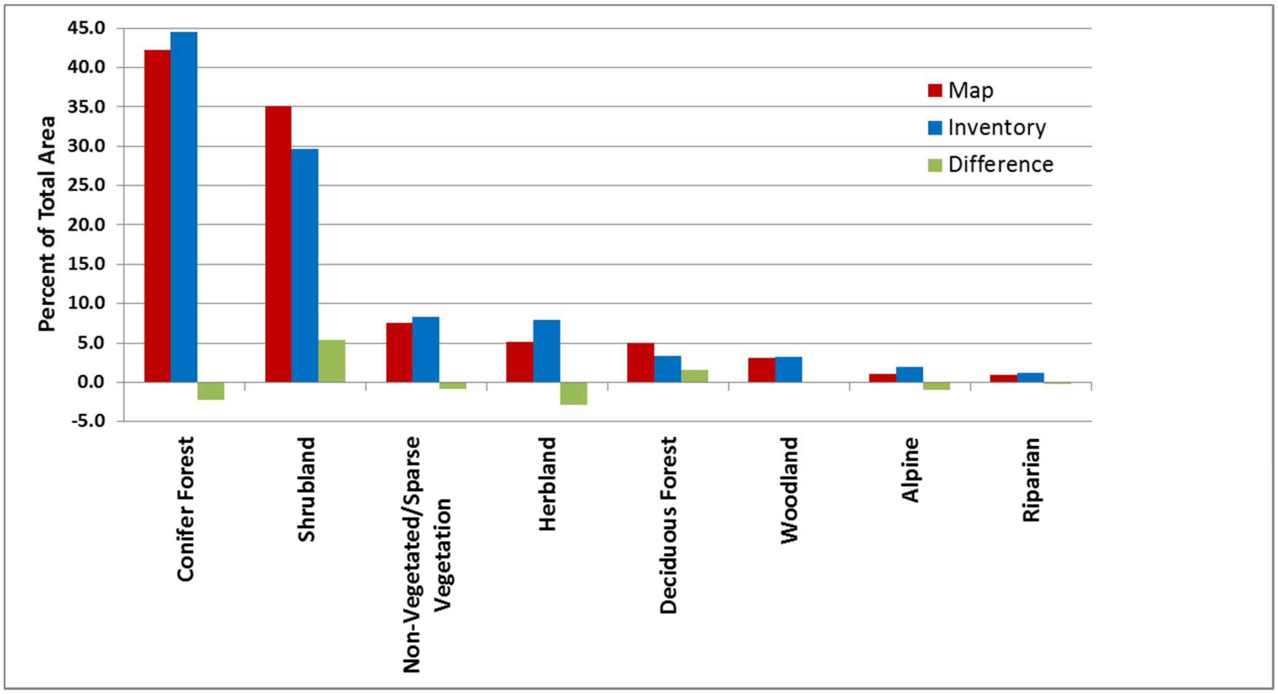

Figure 7: Comparison of mapped and inventory-based estimates of area as a percentage of total area, by vegetation group on the SNF. A positive difference indicates mapped acres exceed inventory acres for that group, while a negative difference shows that inventory acres exceed mapped acres.

Confidence Interval (95 Percent Standard Error) for Vegetation Groups

Using the Forest Inventory Estimation for Analysis tool (FIESTA) (Frescino et al. 2012), it is possible to generate 95 percent standard error values around area estimates of sampled inventory data. By definition, these standard error values represent a 95 percent statistical likelihood that the true value of the estimate ranges within the bounds of the confidence intervals. Standard error values are highly influenced by sample size. In some cases, map classes are not represented well within the inventory data, which may result in relatively large confidence intervals. The FIESTA-based estimates are more appropriate for classes with high sampled area representations. The bounding values give a better idea of where the area estimates should fall, which also informs the accuracy assessment of the maps.

Area estimates from the map product for most vegetation groups were within their corresponding 95 percent confidence interval values based on their inventory-based estimates (**Figure 8**). In fact, the only group that fell outside its associated 95 percent confidence interval was the Shrubland vegetation group. Overall, there was good agreement between the map-based and inventory-based area estimates for the vegetation groups of the SNF. The error matrices presented later in this report may assist in determining where confusion among vegetation groups might have occurred during the mapping process.

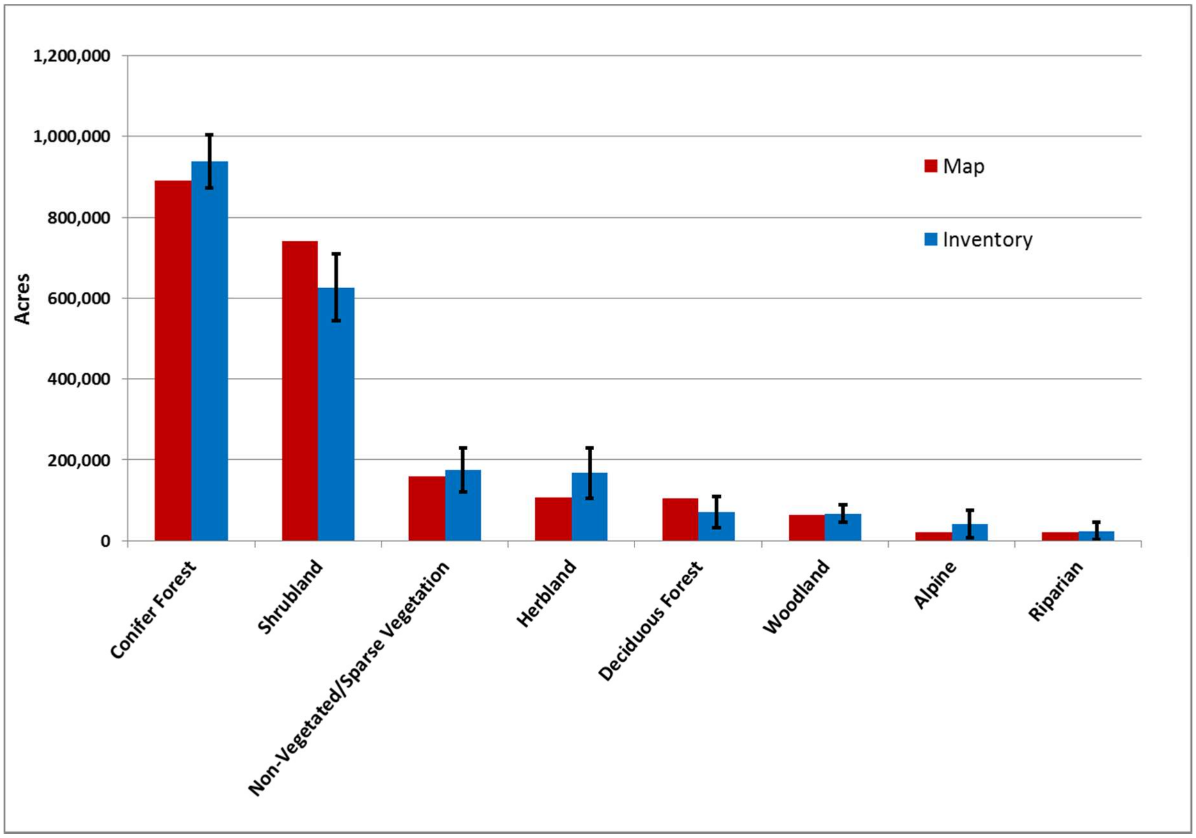

Figure 8: Comparison of mapped and inventory-based estimates of area by vegetation group on the SNF. The 95 percent standard error bars, as derived from the FIESTA program, were added to the inventory-based estimate.

Vegetation Type Comparisons

Vegetation type area estimates were compared between mapped and inventory-predicted areas (**Table 17** and **Figure 9**). Those vegetation types that individually compose at least four percent of the total map acres (i.e., Mountain Big Sagebrush, Douglas-fir, Barren/Sparse Vegetation, Subalpine Fir, Lodgepole Pine, Mountain Shrubland, Subalpine Fir/Whitebark Pine and Grassland) encompass 75 percent of the total map area. Also, the mapped area for these eight vegetation types was within one percent less than their corresponding inventory area, which demonstrates good agreement by the modeling procedure. The largest difference in percent area for all vegetation types was Mountain Big Sagebrush, which was predicted by six percent more area on the map than when compared to the inventory. The second largest difference was Douglas-fir, which was predicted by four percent less area on the map than when compared to the inventory. Mountain Big Sagebrush and Douglas-fir are easily the two largest vegetation classes, and when combined, cover 43 percent of the area on the map compared to 41 percent from the inventory estimate. When considering acres (rather than percentages), three vegetation classes (i.e., Subalpine Fir/Whitebark Pine, Whitebark Pine Mix and Aspen/Conifer) were predicted by over 100 percent more on the map than that from the inventory. The Subalpine Fir/Whitebark Pine class was predicted by over 250 percent, while Whitebark Pine Mix and Aspen/Conifer classes were over 135 percent more acres on the map than from the inventory. But as a group, the Conifer Forest types (i.e., Douglas-fir, Douglas-fir/Lodgepole Pine, Engelmann Spruce, Lodgepole Pine, Ponderosa Pine, Subalpine Fir, Subalpine Fir/Douglas-fir, Subalpine Fir/Whitebark Pine and Whitebark Pine Mix) had good overall agreement between the map predictions (42 percent) and inventory estimates (44 percent). However, the six Shrubland types (i.e., Bitterbrush, Dwarf Sagebrush, Forest Shrubland, Mountain Big Sagebrush, Mountain Shrubland and Wyoming Big Sagebrush), which covers about 35 percent of the map, had a difference of over five percent between the map and inventory-based estimates. Note that the Pinyon-Juniper, Developed, and Agriculture classes were not sampled and thus do not have any associated inventory acres. There are multiple vegetation types with disagreements between the map and inventory-based estimates of area, with Mountain Big Sagebrush and Douglas-fir having the largest differences in predicted acres (**Figure 10**). But overall, the proportion of these differences does not seem very significant compared to the magnitude of the acreage amounts.

In general, comparisons of map units with less than ten inventory plot/conditions are typically not recommended as it may produce unreliable inventory-based area estimates. A more appropriate technique may be to combine some of these map units, when appropriate, so they are represented by a larger number of inventory plot/conditions. Misclassifications and confusion areas are outlined in the error matrix portion of the report.

Table 17: Mapped versus inventory-based estimates of area by existing vegetation types on the SNF. Percent Difference is based on a difference in percentages of total area between mapped and inventory estimates. Vegetation classes are sorted by descending map acres.

Vegetation Class	Code	Map Acres	Map % of Total Area	Inventory Acres	Inventory % of Total Area	Acreage Difference	% Difference
Mountain Big Sagebrush	MSB	492,820	23.4	365,886	17.3	126,934	6.0
Douglas-fir	DF	419,279	19.9	503,818	23.9	-84,540	-4.0
Barren/Sparse Vegetation	BR/SV	148,539	7.0	159,503	7.6	-10,965	-0.5
Subalpine Fir	SA	134,021	6.4	201,351	9.5	-67,331	-3.2
Lodgepole Pine	LP	117,505	5.6	91,929	4.4	25,576	1.2
Mountain Shrubland	MS	99,966	4.7	138,638	6.6	-38,671	-1.8
Subalpine Fir/Whitebark Pine	SAW	86,083	4.1	24,323	1.2	61,760	2.9
Grassland	GR	85,465	4.0	114,013	5.4	-28,548	-1.4
Forest Shrubland	FS	58,972	2.8	33,103	1.6	25,869	1.2
Whitebark Pine Mix	WBmix	58,320	2.8	24,692	1.2	33,627	1.6
Dwarf Sagebrush	DSB	56,561	2.7	46,965	2.2	9,596	0.5
Aspen	AS	54,263	2.6	45,583	2.2	8,680	0.4
Juniper Mix	Jmix	47,535	2.3	53,899	2.6	-6,364	-0.3
Subalpine Fir/Douglas-fir	SAD	39,275	1.9	32,137	1.5	7,138	0.3
Aspen/Conifer	AS/C	32,599	1.5	13,627	0.6	18,972	0.9
Forbland	FO	22,059	1.0	53,178	2.5	-31,119	-1.5
Alpine Vegetation	ALP	21,803	1.0	40,965	1.9	-19,162	-0.9
Wyoming Big Sagebrush	WSB	20,600	1.0	21,063	1.0	-463	0.0
Conifer/Aspen	C/AS	18,687	0.9	11,886	0.6	6,801	0.3
Douglas-fir/Lodgepole Pine	DFL	17,265	0.8	20,377	1.0	-3,111	-0.1
Riparian Woody	RW	16,073	0.8	17,454	0.8	-1,381	-0.1
Engelmann Spruce	ES	12,059	0.6	34,748	1.6	-22,689	-1.1
Bitterbrush	BB	11,843	0.6	21,063	1.0	-9,219	-0.4
Pinyon-Juniper	PJ	8,740	0.4	0	0.0	8,740	0.4
Water	WA	8,506	0.4	15,543	0.7	-7,036	-0.3
Mountain Mahogany	MM	8,186	0.4	12,892	0.6	-4,706	-0.2
Ponderosa Pine	PP	7,046	0.3	4,711	0.2	2,335	0.1
Riparian Herbaceous	RHE	5,039	0.2	7,037	0.3	-1,999	-0.1
Developed	DEV	793	0.0	0	0.0	793	0.0
Agriculture	AGR	484	0.0	0	0.0	484	0.0
Total		**2,110,385**	**100.0**	**2,110,385**	**100.0**	**N/A**	**N/A**

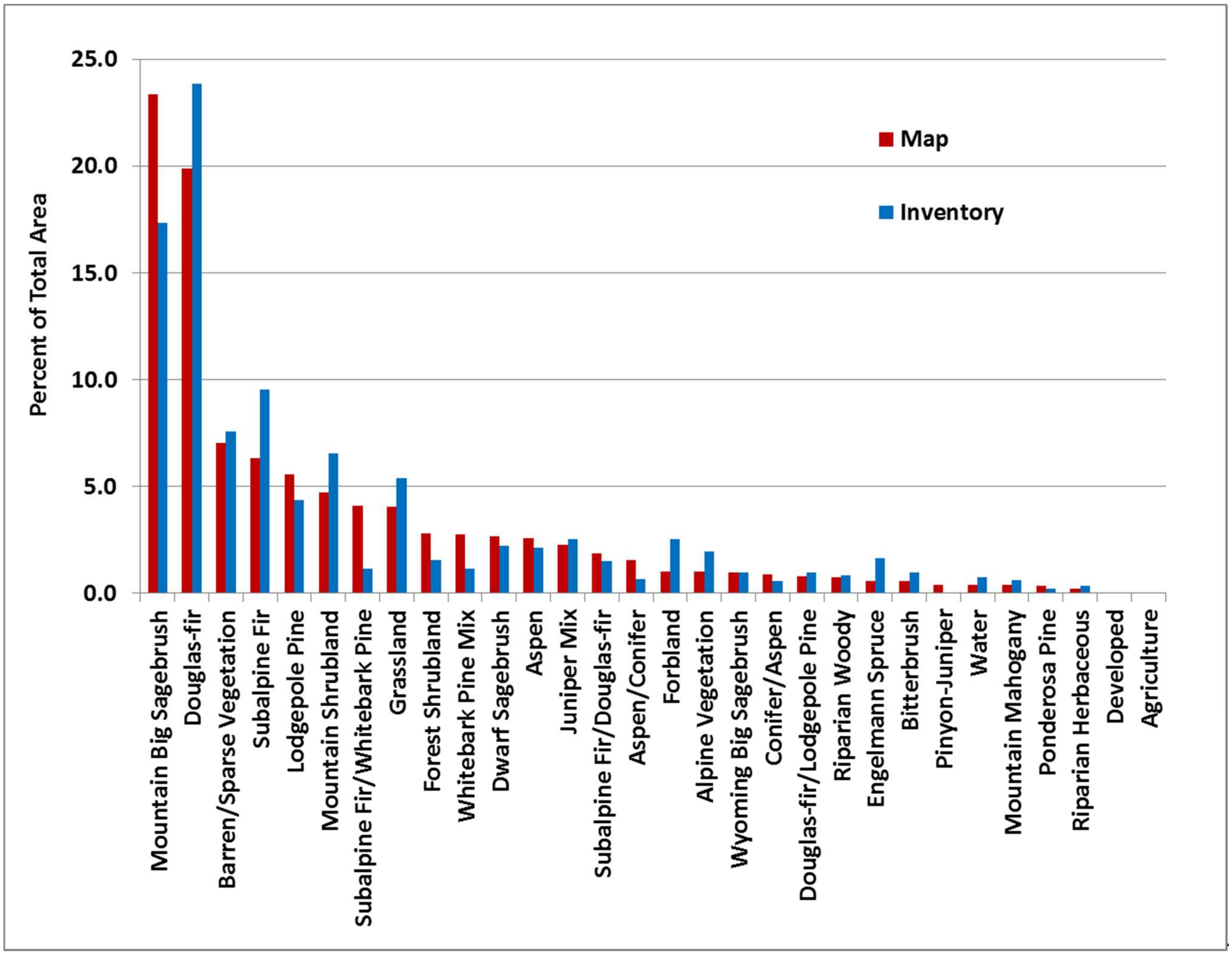

Figure 9: Comparison of mapped and inventory-based estimates of area as a percentage of total area by vegetation type on the SNF.

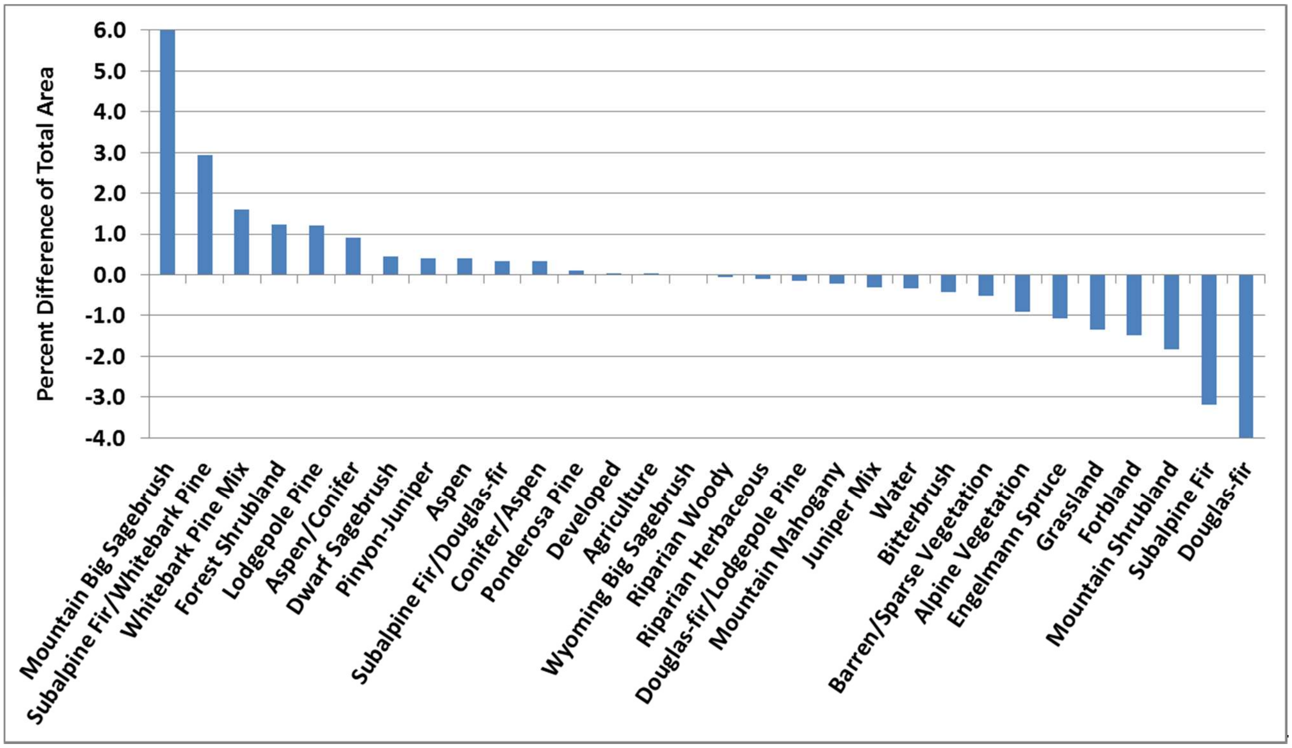

Figure 10: Comparison of mapped and inventory-based estimates of area as a difference in percentage of total area by vegetation type on the SNF**.** A positive difference indicates mapped acres exceed inventory acres for that type, while a negative difference shows that inventory acres exceed mapped acres.

Confidence Interval (95 Percent Standard Error) for Vegetation Types

Using the FIESTA tool to derive 95 percent standard error intervals from the inventory-based area estimates for vegetation type shows some strengths and weaknesses of the mapping process when additional vegetation types are introduced into the modeling process. Comparisons between the mapped areas to their inventory-based confidence intervals are shown in **Figure 11**.

The mapped areas of Mountain Big Sagebrush, Douglas-fir, Subalpine Fir, Subalpine fir/Whitebark Pine, Whitebark Pine Mix and Aspen/Conifer vegetation types all fell outside of their corresponding 95 percent standard error intervals, while the remaining vegetation types were within their respective error intervals. Pinyon-Juniper did not have an inventory-based estimate of area; therefore, no corresponding standard error interval was derived. One-half of the eight largest vegetation classes (each over 4 percent of the mapped area) fell outside their corresponding standard error intervals, including the two largest classes (Mountain Big Sagebrush, Douglas-fir, Subalpine Fir and Subalpine Fir/Whitebark Pine). Although more vegetation classes were within their respective error intervals, it would also seem that several classes, including those with the largest area, were having some difficulty being classified correctly by the modeling process. Some of those classes included mixtures of Subalpine Fir and Whitebark Pine, which potentially may be more troublesome to classify based somewhat on their similar spectral signatures.

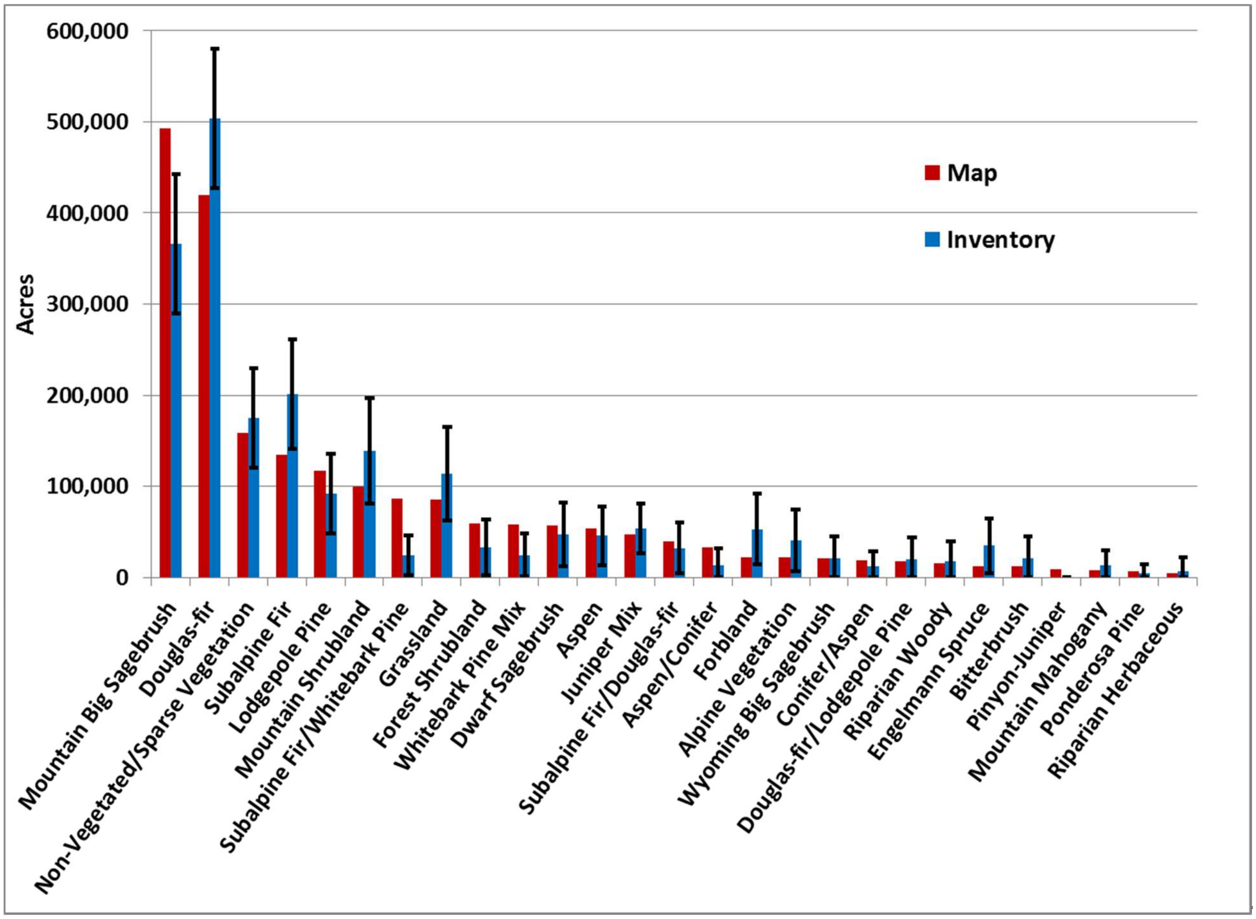

Figure 11: Comparison of mapped and inventory-based estimates of area by vegetation type on the SNF. The 95 percent standard error bars were derived from the inventory-based estimates using FIESTA.

Tree Size Class Comparisons

Map and inventory-based estimates of areas for different tree size (diameter) classes were compared (**Table 18**). Both NF (Nonforest) and TS2 (5 -11.9”) classes were the largest for both inventory and map estimates, having more than 70 percent of the total area of the SNF when combined. The NF class had good agreement between the map and inventory estimates, with only 0.7 percent difference in area estimates, while the TS2 class had a 1.5 percent difference. The remaining tree size classes had larger differences in area estimates, but all had relatively good agreement between map and inventory estimates; ranging from 2.8 to 4 percent differences (**Figure 12**).

Table 18: Mapped and inventory-based estimates of area by forest and woodland tree diameter classes on the SNF. Percent Difference is based on a difference in percentages of total area between mapped and inventory estimates.

Tree Size Code	Tree Size Class DBH or DRC (in)	Map Acres	Map % of Total Area	Inventory Acres	Inventory % of Total Area	Acreage Difference	% Difference
TS1	0 - 4.9”	1,742	0.1	74,415	3.5	-72,674	-3.4
TS2	5 - 11.9”	499,392	23.7	466,684	22.1	32,707	1.5
TS3	12 - 19.9”	361,937	17.2	277,461	13.1	84,476	4.0
TS4	≥ 20”	197,792	9.4	257,415	12.2	-59,623	-2.8
NF	Nonforest	1,049,523	49.7	1,034,410	49.0	15,113	0.7
Total		**2,110,385**	**100.0**	**2,110,385**	**100.0**	**N/A**	**N/A**

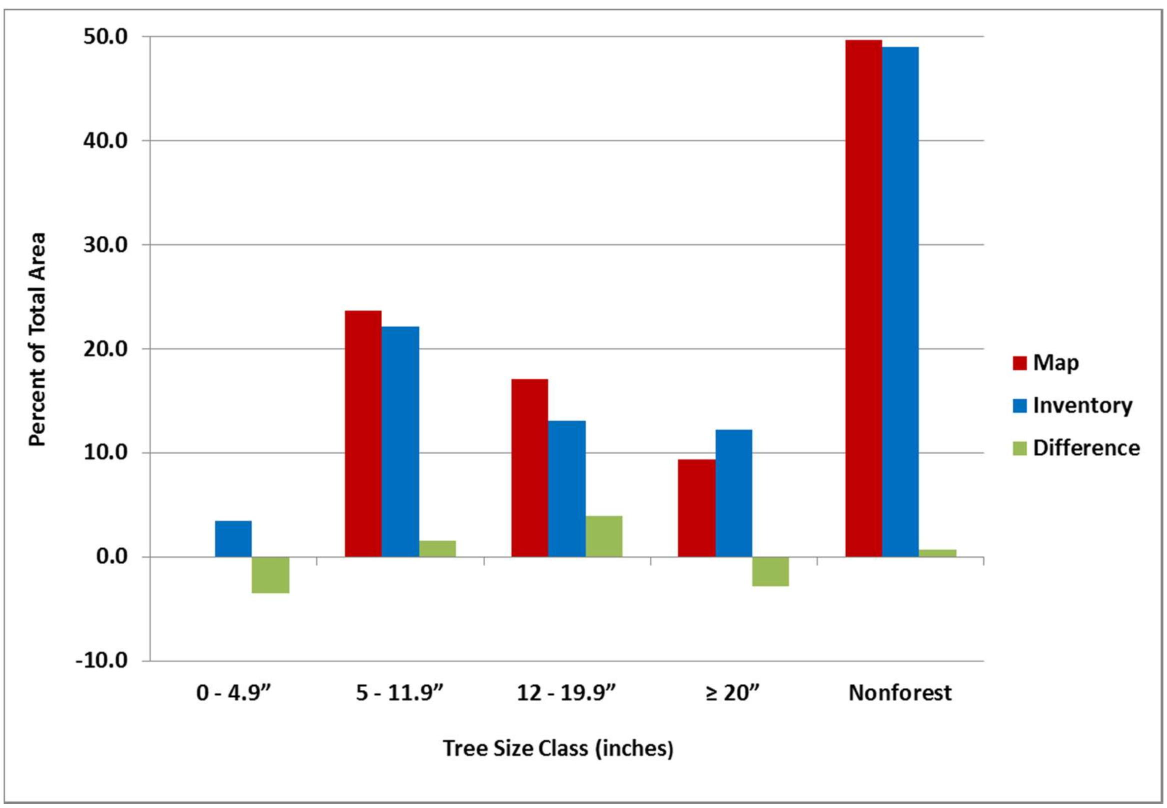

Figure 12: Comparison of mapped and inventory-based estimates of area as a percentage of total area by forest and woodland tree size classes on the SNF. A positive difference indicates estimated mapped acres exceed inventory acres for that class, while a negative difference implies more inventory acres than estimated mapped acres.

Confidence Interval (95 Percent Standard Error) for Tree Size Class

FIESTA-based estimates of 95 percent standard error intervals were generated around the inventory-based area estimates for each tree size class. Two of the five tree size classes (TS1 (0 - 4.9”) and TS3 (12 – 19.9”)) fell outside their corresponding mapped-based area estimate (**Figure 13**). Most of the tree size classes were relatively close in agreement between map and inventory-based estimates of area except for TS1, which had a 97 percent difference in estimates (when comparing acres). This was primarily due to the low map estimate for TS1 (1,742 acres) compared to the inventory-based estimate (74,415 acres). It is essential to recognize the limitations of mapping and assessing tree size classes, such as estimating tree size from aerial imagery or sampling errors associated with measuring size classes in the field.

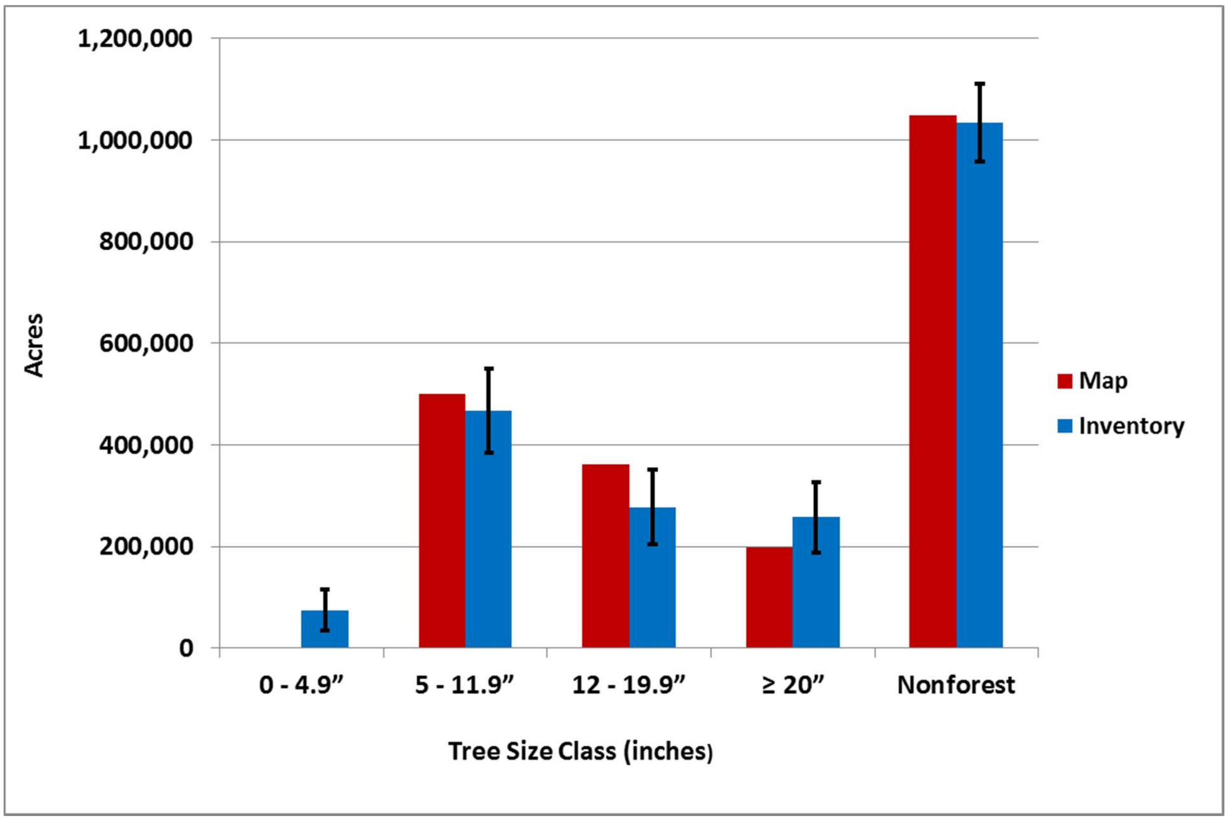

Figure 13: Comparison of mapped and inventory-based estimates of area by tree size classes on the SNF, with 95 percent standard error bars generated from the inventory-based estimates using FIESTA.

Tree Canopy Cover Comparisons

Besides tree size classes, map and inventory-based estimates of areas by different tree canopy cover classes were compared as well (**Table 19**). The TC3 class had the largest difference (8.2 percent) between map and inventory estimates, with the map-based estimate being less (195,226 acres) than the inventory-based value (368,998 acres). In general, all the tree canopy cover classes were in fair agreement when comparing their area estimates, ranging from 6 to 8 percent. It seems that the modeling process had difficulty in predicting tree canopy cover, since every class had a difference in area estimation of over five percent (**Figure 14**). The map-based estimate seems to be over-predicting for the less dense tree cover classes (TC1 and TC2), while under-predicting for the more dense classes (TC3 and TC4). Perhaps the map modeling procedure is trending toward estimating areas that might be difficult to classify into the lower canopy cover classes.

Table 19: Mapped and inventory-based estimates of area by tree canopy cover class on the SNF. Acreage and Percent Differences are based on the difference in percentages of total area between mapped and inventory estimates.

Canopy Cover Code	Canopy Cover Class	Map Acres	Map % of Total Area	Inventory Acres	Inventory % of Total Area	Acreage Difference	% Difference
TC1	10 - 29%	499,690	23.7	341,160	16.2	158,530	7.5
TC2	30 - 39%	300,952	14.3	172,250	8.2	128,703	6.1
TC3	40 - 59%	195,226	9.3	368,998	17.5	-173,772	-8.2
TC4	≥ 60%	64,994	3.1	193,567	9.2	-128,573	-6.1

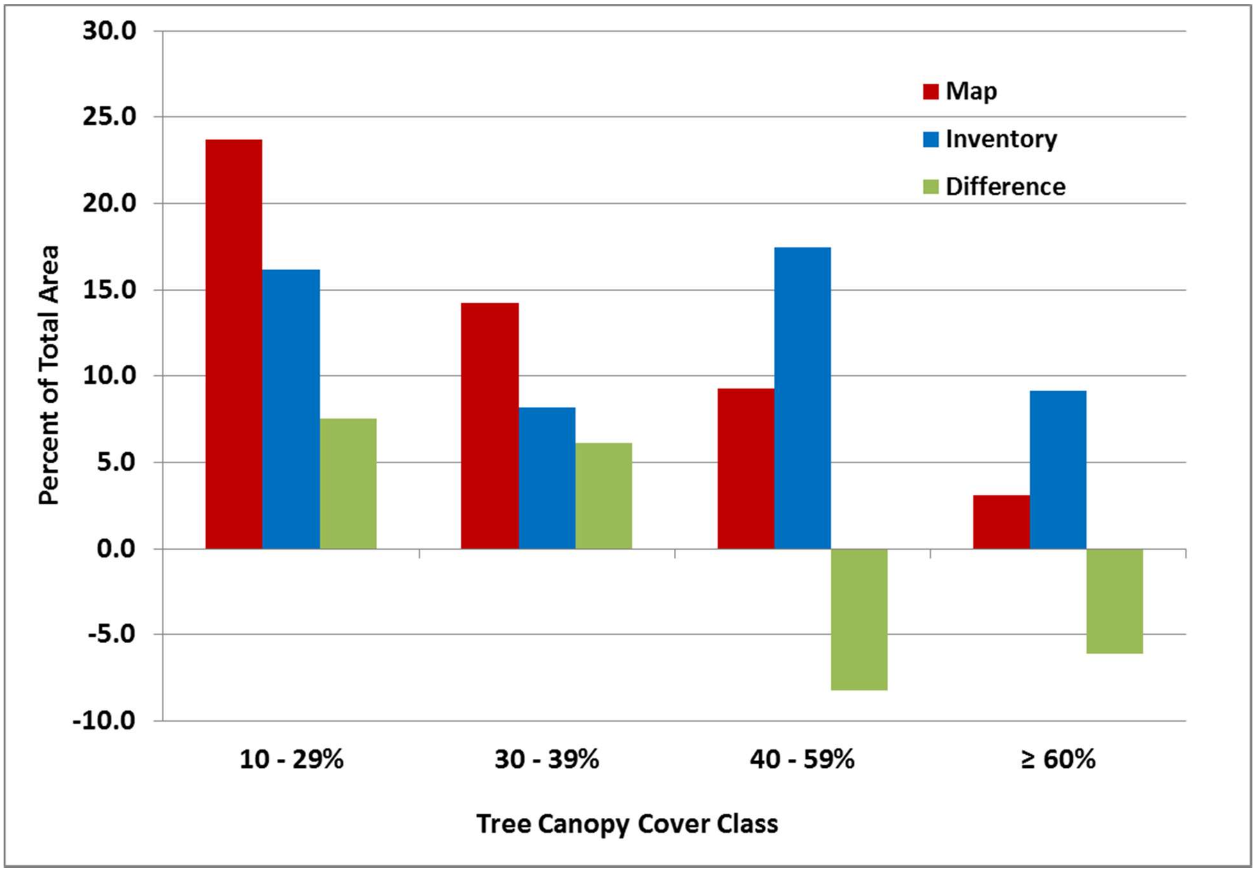

Figure 14: Comparison of mapped and inventory-based estimates of area as a percentage of total area by tree canopy cover classes on the SNF. A positive difference indicates estimated mapped acres exceed inventory acres for that class, while a negative difference implies more inventory acres than estimated mapped acres.

Shrub Canopy Cover Comparisons

In addition to area by tree canopy cover, map and inventory-based estimates of areas for different shrub cover classes were also evaluated (**Table 20**, **Figure 15**). A large majority of the shrub canopy cover area estimates from the map were over predicting compared to their respective classes for the inventory-based estimates, with SC2 being the exception. Area estimates for the mid-range shrub canopy cover classes (SC2 and SC3) were relatively close between map and inventory-based values (near one percent); while the low and high cover classes (SC1 and SC4) had larger differences.

Table 20: Mapped and inventory-based estimates of area by shrub canopy cover class on the SNF. Acreage and Percent Differences are based on the difference in percentages of total area between mapped and inventory estimates.

Canopy Cover Code	Canopy Cover Class	Map Acres	Map % of Total Area	Inventory Acres	Inventory % of Total Area	Acreage Difference	% Difference
SC1	10 - 24%	98,835	4.7	42,740	2.0	56,095	2.7
SC2	15 - 24%	141,660	6.7	168,467	8.0	-26,807	-1.3
SC3	25 - 34%	195,137	9.2	171,851	8.1	23,287	1.1
SC4	≥ 35%	321,203	15.2	243,658	11.5	77,545	3.7

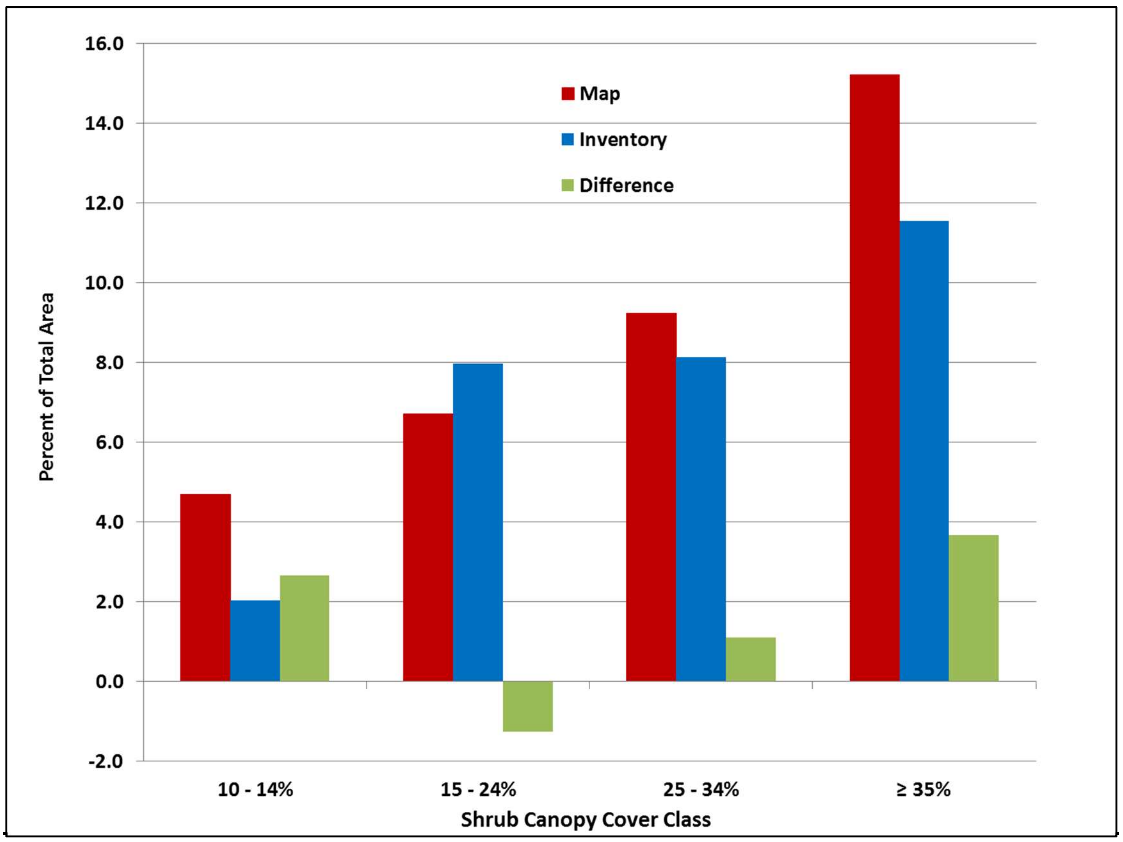

Figure 15: Comparison of mapped and inventory-based estimates of area as a percentage of total area by shrub canopy cover class on the SNF. A positive difference indicates estimated

mapped acres exceed inventory acres for that class, while a negative difference implies more inventory acres than estimated mapped acres.

Confidence Interval (95 Percent Standard Error) for Canopy Cover Class

FIESTA estimates of 95 percent standard error confidence intervals for the inventory-based area estimates were created for each canopy cover class (**Figure 16**). The only two canopy cover classes (map-based estimates) within their corresponding 95 percent error bars from the inventory-based estimates were SC2 (15 – 24%) and SC3 (25 – 34%). The remaining cover classes were typically much farther outside their error bars, ranging from 28 percent to as high as 131 percent differences in estimates ((map – inventory acres) / inventory acres). The tree canopy cover class map estimates generally fared worse than the shrub estimates.

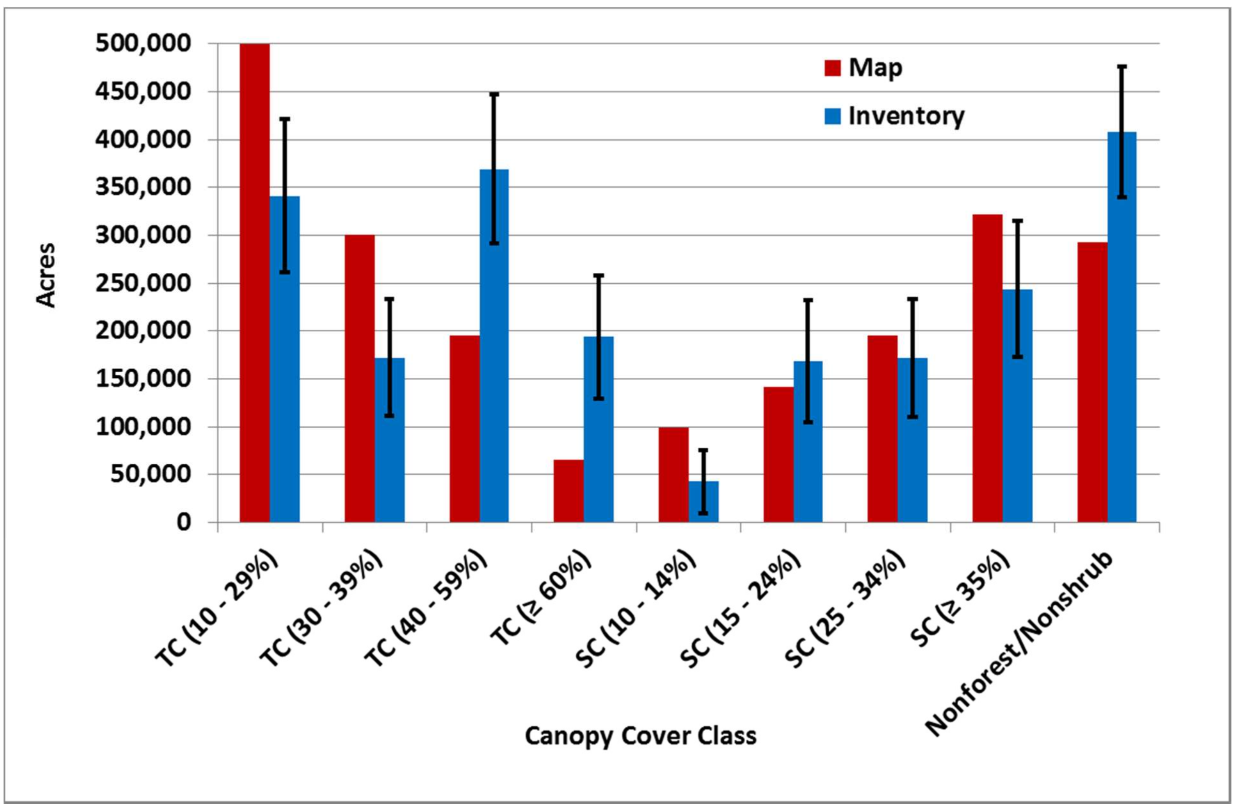

Figure 16: Comparison of mapped and inventory-based estimates of area by canopy cover class on the SNF, with 95 percent standard error bars generated from the inventory-based estimates using FIESTA.

Site-Specific Accuracy Assessment

Accuracy assessments are an essential part of any modeling or remote sensing project; not only for comparing different mapping methods and sensors, but also for providing information on the reliability and usefulness of those techniques for a particular application. Most importantly, accuracy assessments provide guidance in the decision making process by providing a measure of reliability for the mapped classes, as well as allowing users to understand a map's limitations (Nelson et al. 2015).

Error Matrix

The error (confusion) matrix is a standard tool used for presenting results of an accuracy assessment. In general, it is a square array where both the classified reference (observed) and image (mapped) data are ordered and compared for class agreement on the diagonally intersected cells; typically rows in the matrix represent the classified image data while columns represent the observed data (Story and Congalton 1986). The error matrix can be used to determine the accuracy of classes and any degree of confusion between classes.

The *observed* classes (FIA inventory plots) are presented in the columns and the *mapped* classes (modeled results) in the rows of the vegetation group error matrix (**Table 21**). For accuracy assessments, only the condition-level data that includes the center subplot of an FIA plot is used, since it corresponds to the actual coordinates of that FIA plot when intersecting it against mapped values. As a result, a total number of 306 FIA plots were available for the following accuracy assessment tables, instead of the 348 previously stated (e.g., some FIA plots did not have a center subplot accessible). The highlighted diagonal cells tally the number of inventory plots that are in agreement with the intersected mapped classes. Percent class accuracies are calculated by dividing the number of correct classifications (diagonal cells) by each class total. For each class there are two main types of accuracies generated by the matrix: a "user's" and "producer's" accuracy. A "user's accuracy" indicates errors of commission, where a class has been mapped in places where it does not exist. A "producer's accuracy" indicates errors of omission, where a class has not been mapped where it exists on the ground. Not applicable (N/A) is used to indicate when information for a certain cell calculation is not available, which is primarily due to a lack of inventory plots for a specific row or column of an error matrix.

Vegetation Group Accuracies

The Conifer Forest and Woodland vegetation groups each had the highest producer's accuracy at 90 percent (although the Conifer Forest group had more plots), followed by the Shrubland group at 85 percent. The Riparian vegetation group had a lower producer's accuracy of 50 percent, with a much lower number of plots in that group. The Deciduous Forest vegetation group followed with an accuracy of 40 percent, while the remaining groups all had lower accuracies. Some issues related to mapping involve separating "fuzzy" categorical boundaries between different mapping groups. Generally, it is difficult to accurately separate groups within transition zones. In addition, inventory plots and vegetation group polygons may encompass multiple vegetation groups, leading to additional confusion. The overall classification accuracy for the eight vegetation groups was 77 percent.

Table 21: Error matrix for vegetation groups on the SNF. FIA plots were used as an independent source to evaluate the classification accuracies of the modeled map classes. Overall classification accuracy across eight vegetation groups was 77 percent.

		INVENTORY PLOTS									
	Map Group	**Conifer Forest**	**Shrubland**	**Herbland**	**Deciduous Forest**	**Non-Vegetated/Sparse**	**Woodland**	**Riparian**	**Alpine**	**Total**	**User's % Accuracy**
MAP CLASS	**Conifer Forest**	132	4	2	3	5		1		147	**90**
	Shrubland	7	73	8	3	4	1	1	3	100	**73**
	Herbland	1	5	8		8				22	**36**
	Deciduous Forest	5	3		4					12	**33**
	Non-Vegetated/Sparse Vegetation	1		3		6			1	11	**55**
	Woodland		1				9			10	**90**
	Riparian			1				2		3	**67**
	Alpine								1	1	**100**
	Total	146	86	22	10	23	10	4	5	306	**77**
	Producer's % Accuracy	**90**	**85**	**36**	**40**	**26**	**90**	**50**	**20**	**77**	

Vegetation Type Accuracies

Accuracy assessment results typically decrease when the complexity of mapping more refined classes occurs. The overall classification accuracies for 27 vegetation types (

Table 22) should consequently be lower than that for eight vegetation groups (**Table 21**). As expected, accuracies decline due to a larger number of classes and distinctions made to

		INVENTORY PLOTS																			
	Map Unit	**Mountain Big Sagebrush**	**Douglas-fir**	**Subalpine Fir**	**Grassland**	**Lodgepole Pine**	**Subalpine Fir/Whitebark Pine**	**Subalpine Fir/Douglas-fir**	**Non-Vegetated/Sparse Vegetation**	**Mountain Shrubland**	**Dwarf Sagebrush**	**Juniper Mix**	**Aspen**	**Whitebark Pine Mix**	**Forest Shrubland**	**Aspen/Conifer**	**Engelmann Spruce**	**Conifer/Aspen**	**Mountain Mahogany**	**Riparian Herbaceous**	**Bitterbrush**
MAP CLASS	**Mountain Big Sagebrush**	39	2	2	6				2	6	2		1								3
	Douglas-fir		47	1	1	1		1	3	1						1	2	2			
	Subalpine Fir	1	4	15		3	1	2						1			1				
	Grassland	4			7				8						1						
	Lodgepole Pine		4	3		9		1							1						
	Subalpine Fir/Whitebark	1		4					2					3			2				
	SubalpineFir/Douglas-fir		6	4				1													
	Non-Vegetated/Sparse				1		1		6												
	Mountain Shrubland	1		1					1	4	1		1		1						
	Dwarf Sagebrush	2			1				1	2	3	1									
	Juniper Mix	1										6									
	Aspen	1	1							1			2			1					
	Whitebark Pine Mix		3	1			1							1							
	Forest Shrubland		2							1			1		1						
	Aspen/Conifer			2						1			1								
	Engelmann Spruce		1	2													1				
	Conifer/Aspen		2																		
	Mountain Mahogany																		2		
	Riparian Herbaceous				1															1	
	Bitterbrush	1								1											
	Wyoming Big Sagebrush	2																			
	Douglas-fir/Lodgepole		1																		
	Ponderosa Pine		1																		
	Riparian Woody																				
	Alpine Vegetation																				
	Forbland					1															
	Pinyon-Juniper											1									
	Total	53	74	35	17	14	3	5	23	17	6	8	6	5	4	2	6	2	2	1	3
	Producer's % Accuracy	**74**	**64**	**43**	**41**	**64**	**0**	**20**	**26**	**24**	**50**	**75**	**33**	**20**	**25**	**0**	**17**	**0**	**100**	**100**	**0**

account for a greater variety of vegetation types. The overall accuracy for the 27 vegetation types was 49 percent, with clear distinctions among certain classes. Zero plots/conditions existed for Agriculture, Developed, and Water; therefore, those types do not affect and are not included in the overall classification accuracy (

Table 22).

		INVENTORY PLOTS																			
	Map Unit	**Mountain Big Sagebrush**	**Douglas-fir**	**Subalpine Fir**	**Grassland**	**Lodgepole Pine**	**Subalpine Fir/Whitebark Pine**	**Subalpine Fir/Douglas-fir**	**Non-Vegetated/Sparse Vegetation**	**Mountain Shrubland**	**Dwarf Sagebrush**	**Juniper Mix**	**Aspen**	**Whitebark Pine Mix**	**Forest Shrubland**	**Aspen/Conifer**	**Engelmann Spruce**	**Conifer/Aspen**	**Mountain Mahogany**	**Riparian Herbaceous**	**Bitterbrush**
MAP CLASS	**Mountain Big Sagebrush**	39	2	2	6				2	6	2		1								3
	Douglas-fir		47	1	1	1		1	3	1						1	2	2			
	Subalpine Fir	1	4	15		3	1	2						1			1				
	Grassland	4			7				8						1						
	Lodgepole Pine		4	3		9		1							1						
	Subalpine Fir/Whitebark	1		4					2					3			2				
	SubalpineFir/Douglas-fir		6	4				1													
	Non-Vegetated/Sparse				1		1		6												
	Mountain Shrubland	1		1					1	4	1		1		1						
	Dwarf Sagebrush	2			1				1	2	3	1									
	Juniper Mix	1										6									
	Aspen	1	1							1			2			1					
	Whitebark Pine Mix		3	1			1							1							
	Forest Shrubland		2							1			1		1						
	Aspen/Conifer			2						1			1								
	Engelmann Spruce		1	2													1				
	Conifer/Aspen		2																		
	Mountain Mahogany																		2		
	Riparian Herbaceous				1															1	
	Bitterbrush	1								1											
	Wyoming Big Sagebrush	2																			
	Douglas-fir/Lodgepole		1																		
	Ponderosa Pine		1																		
	Riparian Woody																				
	Alpine Vegetation																				
	Forbland					1															
	Pinyon-Juniper											1									
	Total	53	74	35	17	14	3	5	23	17	6	8	6	5	4	2	6	2	2	1	3
	Producer's % Accuracy	**74**	**64**	**43**	**41**	**64**	**0**	**20**	**26**	**24**	**50**	**75**	**33**	**20**	**25**	**0**	**17**	**0**	**100**	**100**	**0**

Douglas-fir had the largest number of plots (74), which resulted in a producer's accuracy of 64 percent. Mountain Big Sagebrush had fewer plots (53), but a better producer's accuracy of 74 percent. However, the Mountain Big Sagebrush user's accuracy dropped to 56 percent, which may indicate potential confusion among other sagebrush classes. The remaining types with 50 percent or greater producer's accuracy included Lodgepole Pine (64 percent), Dwarf Sagebrush (50 percent, 6 plots), Juniper Mix (75 percent, 8 plots), Mountain Mahogany (100 percent, 2 plots), Riparian Herbaceous (100 percent, 1 plot) and Ponderosa Pine (100 percent, 1 plot).

For the user's accuracy, vegetation types with greater than 50 percent accuracy were: Mountain Big Sagebrush (56 percent), Douglas-fir (73 percent), Subalpine Fir (54 percent), Lodgepole Pine (50 percent), Non-Vegetated/Sparse Vegetation (55 percent), Juniper Mix (86 percent, 7 plots), Mountain Mahogany (100 percent, 2 plots), Riparian Herbaceous (50 percent, 2 plots), Douglas-fir/Lodgepole Pine (50 percent, 2 plots), Ponderosa Pine (50 percent, 2 plots), Riparian Woody (100 percent, 1 plot) and Alpine Vegetation (100 percent, 1 plot). Vegetation types with fewer than 10 plots were indicated since they have the potential to obtain relatively high user accuracies if only a few plots are correctly classified and no plots from other types are mistakenly classified into that particular type.

A map modeling process may be evaluated by reviewing how the model mapped an individual vegetation type. For example, the Douglas-fir type had the largest number of plots (74) in the FIA data set; 47 of 74 plots were correctly classified by the model. Douglas-fir type had a producer's accuracy of 64 percent and user's accuracy of 73 percent. However, by reviewing the Inventory Plots/Douglas-fir column, there are several other modeled vegetation types that overlap with Douglas-fir plots. Some of the map unit classes that were confused, but reasonably misclassified by being within the same vegetation group as Douglas-fir, include: Subalpine Fir/Douglas-fir (6 plots), Subalpine Fir (4 plots), Lodgepole Pine (4 plots), Whitebark Pine Mix (3 plots), Douglas-fir/Lodgepole Pine (1 plot), Ponderosa Pine (1 plot) and Engelmann Spruce (1 plot). Some of the map unit classes that were confused with Douglas-fir, but likely not reasonably misclassified by being outside the same vegetation group as Douglas-fir, were: Mountain Big Sagebrush (2 plots), Forest Shrubland (2 plots), Conifer/Aspen (2 plots) and Aspen (1 plot).

A similar evaluation can be done while looking along the Map Unit Class/Douglas-fir row, where there are several other vegetation classes of inventory plots that intersected with a modeled Douglas-fir vegetation type. Some inventory plot classes that were located within a modeled Douglas-fir vegetation type, which were reasonably misclassified by being within the same vegetation group as Douglas-fir, include: Douglas-fir/Lodgepole Pine (2 plots), Engelmann Spruce (2 plots), Lodgepole Pine (1 plot), Subalpine Fir (1 plot) and Subalpine Fir/Douglas-fir (1 plot). Some inventory plot classes that were located within the modeled Douglas-fir vegetation type, but were not reasonably misclassified by being outside the same vegetation group as Douglas-fir, consist of: Non-Vegetated/Sparse Vegetation (3 plots), Conifer/Aspen (2 plots), Aspen/Conifer (1 plot), Mountain Shrubland (1 plot), Riparian Woody (1 plot), Forbland (1 plot) and Grassland (1 plot). A map user may compare other map classes in a similar manner to determine the level of agreement between a specific map class and its corresponding FIA plot data. A user may also compare producer versus user accuracy values for a specific vegetation type to analyze similarities or differences between the two accuracy values.

It should also be noted that there are several class accuracies with either a 100 percent or zero percent accuracy (

		INVENTORY PLOTS																			
	Map Unit	Mountain Big Sagebrush	Douglas-fir	Subalpine Fir	Grassland	Lodgepole Pine	Subalpine Fir/Whitebark Pine	Subalpine Fir/Douglas-fir	Non-Vegetated/Sparse Vegetation	Mountain Shrubland	Dwarf Sagebrush	Juniper Mix	Aspen	Whitebark Pine Mix	Forest Shrubland	Aspen/Conifer	Engelmann Spruce	Conifer/Aspen	Mountain Mahogany	Riparian Herbaceous	Bitterbrush
MAP CLASS	Mountain Big Sagebrush	39	2	2	6				2	6	2		1								3
	Douglas-fir		47	1	1	1		1	3	1						1	2	2			
	Subalpine Fir	1	4	15		3	1	2						1			1				
	Grassland	4			7				8						1						
	Lodgepole Pine		4	3		9		1							1						
	Subalpine Fir/Whitebark	1		4					2					3			2				
	SubalpineFir/Douglas-fir		6	4				1													
	Non-Vegetated/Sparse				1		1		6												
	Mountain Shrubland	1		1					1	4	1		1		1						
	Dwarf Sagebrush	2			1				1	2	3	1									
	Juniper Mix	1										6									
	Aspen	1	1							1			2			1					
	Whitebark Pine Mix		3	1			1							1							
	Forest Shrubland		2							1			1		1						
	Aspen/Conifer			2						1			1								
	Engelmann Spruce		1	2													1				
	Conifer/Aspen		2																		
	Mountain Mahogany																		2		
	Riparian Herbaceous				1															1	
	Bitterbrush	1								1											
	Wyoming Big Sagebrush	2																			

Douglas-fir/Lodgepole		1																		
Ponderosa Pine		1																		
Riparian Woody																				
Alpine Vegetation																				
Forbland					1															
Pinyon-Juniper											1									
Total	53	74	35	17	14	3	5	23	17	6	8	6	5	4	2	6	2	2	1	3
Producer's % Accuracy	**74**	**64**	**43**	**41**	**64**	**0**	**20**	**26**	**24**	**50**	**75**	**33**	**20**	**25**	**0**	**17**	**0**	**100**	**100**	**0**

Table 22). This is commonly found were there are very few plots within an individual vegetation class, so that it is either misclassified or correctly classified. A better representation on model performance might be gained by collapsing similar several vegetation classes so that a minimum number of plots are available for each class (five or ten plots per class, for example).

Table 22: Error matrix for vegetation types on the SNF. FIA plots were used as a validation data set to produce the classification accuracies of the modeled map unit classes. Overall classification accuracy across 27 vegetation types was 49 percent.

MAP CLASS	INVENTORY PLOTS																												
Map Unit	Mountain Big Sagebrush	Douglas-fir	Subalpine Fir	Grassland	Lodgepole Pine	Subalpine Fir/Whitebark Pine	Subalpine Fir/Douglas-fir	Non-Vegetated/Sparse Vegetation	Mountain Shrubland	Dwarf Sagebrush	Juniper Mix	Aspen	Whitebark Pine Mix	Forest Shrubland	Aspen/Conifer	Engelmann Spruce	Conifer/Aspen	Mountain Mahogany	Riparian Herbaceous	Bitterbrush	Wyoming Big Sagebrush	Douglas-fir/Lodgepole Pine	Ponderosa Pine	Riparian Woody	Alpine Vegetation	Forbland	Pinyon-Juniper	Total	User's % Accuracy
Mountain Big Sagebrush	39	2	2	6				2	6	2		1								3	3			1	3			70	**56**
Douglas-fir		47	1	1	1		1	3	1						1	2	2					2		1		1		64	**73**
Subalpine Fir	1	4	15		3	1	2						1			1												28	**54**
Grassland	4			7				8						1												1		21	**33**
Lodgepole Pine		4	3		9		1							1														18	**50**
Subalpine Fir/Whitebark	1		4					2					3			2												12	**0**
SubalpineFir/Douglas-fir		6	4				1																					11	**9**
Non-Vegetated/Sparse				1		1		6																	1	2		11	**55**
Mountain Shrubland	1		1					1	4	1		1		1														10	**40**
Dwarf Sagebrush	2			1				1	2	3	1																	10	**30**
Juniper Mix	1										6																	7	**86**
Aspen	1	1							1			2			1													6	**33**
Whitebark Pine Mix		3	1			1							1															6	**17**
Forest Shrubland		2							1			1		1												1		6	**17**
Aspen/Conifer			2						1			1																4	**0**
Engelmann Spruce		1	2													1												4	**25**
Conifer/Aspen		2																										2	**0**
Mountain Mahogany																		2										2	**100**
Riparian Herbaceous				1															1									2	**50**
Bitterbrush	1								1																			2	**0**
Wyoming Big Sagebrush	2																											2	**0**
Douglas-fir/Lodgepole		1																				1						2	**50**
Ponderosa Pine		1																					1					2	**50**
Riparian Woody																								1				1	**100**
Alpine Vegetation																									1			1	**100**
Forbland					1																							1	**0**
Pinyon-Juniper											1																	1	**0**
Total	53	74	35	17	14	3	5	23	17	6	8	6	5	4	2	6	2	2	1	3	3	3	1	3	5	5	0	306	**49**
Producer's % Accuracy	**74**	**64**	**43**	**41**	**64**	**0**	**20**	**26**	**24**	**50**	**75**	**33**	**20**	**25**	**0**	**17**	**0**	**100**	**100**	**0**	**0**	**33**	**100**	**33**	**20**	**0**	N/A	**49**	

Tree Size Class Accuracies

For the various tree size classes, the 5 - 11.9" diameter class had the best producer's accuracy (excluding Nonforest) at 63 percent (**Table 23**). However, the remaining tree size classes were below 40 percent. The corresponding user's accuracy values for the remaining applicable tree size classes are also below 40 percent as well (excluding the 5 – 11.9" and Nonforest classes). Neither DBH nor DRC are readily determinable using imagery from above; therefore, class separation relies heavily on shared spectral characteristics of similarly sized classes. It is generally more difficult to remotely-estimate tree diameters for woodland species (compared to forest species), since their tree form typically does not fit into a consistent diameter-to-crown ratio. Overall classification accuracy across all five tree size classes was 64 percent.

Table 23: Error matrix for tree size classes on the SNF. FIA plots were used as a validation data set to produce the classification accuracies for the modeled tree size map classes. Overall classification accuracy across five tree size classes was 64 percent.

		INVENTORY PLOTS						
	Size Class (DBH or DRC, inches)	**0 - 4.9"**	**5 - 11.9"**	**12 - 19.9"**	**≥ 20"**	**Nonforest**	**Total**	**User's % Accuracy**
MAP CLASS	**0 - 4.9"**						0	**N/A**
	5 - 11.9"	6	45	8	10	9	78	**58**
	12 - 19.9"	2	23	16	20	4	65	**25**
	≥ 20"			13	10	3	26	**38**
	Nonforest	2	4	5	2	124	137	**91**
	Total	10	72	42	42	140	**306**	**64**
	Producer's % Accuracy	**0**	**63**	**38**	**24**	**89**	**64**	

Canopy Cover Class Accuracies

The classification matrix for percent canopy cover indicates mixed results (**Table 24).** Three cover classes were all near the highest producer's accuracy, which included: Nonforest/Nonshrubland at 54 percent, Tree Canopy Class 1 (TC1, 10 - 29%) at 53 percent, followed by Shrub Canopy Class 4 (SC4, ≥35%) at 52 percent. Prior assessments have shown that shrub cover classes are harder to map than tree cover classes, which is largely supported by comparing the tree and shrub canopy cover class accuracies. Generally, remotely-sensed imagery should be able to correctly classify canopy cover classes more than tree size (diameter) classes. However, only about one-third of the individual canopy cover classes (both tree and shrub classes) were above 50 percent accuracy (producer's and user's combined). Also, the overall classification accuracy across nine canopy cover classes was 40 percent, which is lower than the overall classification accuracy for the five tree size classes (64 percent).

Table 24: Error matrix for canopy cover classes on the SNF. FIA plots were used as a validation data set to produce the classification accuracies for the modeled canopy cover map classes. Overall classification accuracy across nine canopy cover classes was 40 percent.

		INVENTORY PLOTS										
	Canopy Class (% cover)	**TC1 (10 – 29%)**	**TC2 (30 - 39%)**	**TC3 (40 - 59%)**	**TC4 (≥ 60%)**	**SC1 (10 - 14%)**	**SC2 (15 - 24%)**	**SC3 (25 - 34%)**	**SC4 (≥ 35%)**	**Nonforest/ Nonshrubland**	**Total**	**User's % Accuracy**
MAP CLASS	**TC1 (10 - 29%)**	28	12	11	4	1	4	1	2	5	68	**41**
	TC2 (30 - 39%)	11	11	21	9					3	55	**20**
	TC3 (40 - 59%)	2	4	18	5						29	**62**
	TC4 (≥ 60%)	1		6	10						17	**59**
	SC1 (10 - 14%)	1					4	2	5	7	19	**0**
	SC2 (15 - 24%)	1			1	1	1	3	1	2	10	**10**
	SC3 (25 - 34%)					2	7	9	7	3	28	**32**
	SC4 (≥ 35%)	7		1		1	6	7	17	5	44	**39**
	Nonforest/Nonshrubland	2				1	1	2	1	29	36	**81**
	Total	**53**	**27**	**57**	**29**	**6**	**23**	**24**	**33**	**54**	**306**	**40**
	Producer's % Accuracy	**53**	**41**	**32**	**34**	**0**	**4**	**38**	**52**	**54**	**40**	

Conclusions for Accuracy Assessment

Since its inception in the early 1980s, thematic accuracy assessment of remote sensing data has consistently been a particularly challenging portion of the mapping process. Despite its critical importance, there are a wide variety of data types and methods that can be used to attain relatively similar goals. Although a number of definitive standards have been adopted throughout the remote sensing community over the years, there still remains a great degree of uncertainty to the question of how best to perform a reliable, repeatable, and realistic accuracy assessment.

Although optimum reference datasets for accuracy assessment would be designed specifically for use with the final map product, this is often very cost prohibitive and time-consuming. The use of inventory data, such as FIA, involves trade-offs between resolution and reliability. FIA data provide a statistically robust, spatially distributed, unbiased sample that is readily available as a source of information that can serve as a base-level accuracy assessment for mid-level mapping. When used for accuracy assessments, consideration should be given to address differences in the sample design and data collection methods compared with the map products.

Project Data Files

Feature Class and Layer Files

The existing vegetation polygon feature class and its Federal Geographic Data Committee (FGDC)-compliant metadata are stored and maintained in ESRI geodatabase format within individual forest ArcSDE (Spatial Database Engine) schemas at the Forest Service Enterprise Data Center. This feature class containing a union of vegetation type, tree and shrub cover class, and tree size class serves as the authoritative source data. It is recommended that the feature class be accessed by Forest Service users through Citrix using ESRI ArcGIS software applications to optimize performance (https://apps.fs.usda.gov/Citrix/auth/login.aspx). ArcGIS layer files (*.lyr) containing polygon-feature symbology for vegetation type, cover class, and tree size class can be accessed through Citrix from ArcGIS applications at T:\FS\Reference\GIS\r04_snf\LayerFile\Vegetation. More information on procedures for accessing geospatial data through Citrix at the Data Center can be found at: http://fsweb.egis.fs.fed.us/EGIS_tools/GettingStartedEDC.shtml.

Ancillary and Intermediate Data

All other data related to this project, including ancillary and intermediate geospatial data, reference site information, and supporting documentation are stored and archived as the trusted source data set on the Intermountain Regional Office local Network Attached Storage (NAS) device and tape backup system. Assistance in accessing the authoritative source data through Citrix or obtaining a copy of ancillary and intermediate data sets may be facilitated by Regional Office project partners.

Conclusion

The status and condition of existing vegetation on the SNF is a critical factor for many of its land-management decisions. When used in conjunction with the associated maps, taxonomic keys, data, and map unit descriptions, this document provides the foundation for supporting applicable land management decisions using the best-available science. Since these products reflect a single point in time, specifically 2011 conditions, land managers should develop a strategy for maintaining their initial investment in the future. Maintenance and future updates will keep the vegetation map current and useful as vegetation disturbances, treatments, or gradual changes occur over time.

References

Breiman, L. 2001. Random Forests. *Machine Learning*, *45*, 5–32.

Brewer, C., B. Schwind, R. Warbington, W. Clerke, P. Krosse, L. Suring, and M. Schanta. 2005. Section 3: Existing Vegetation Mapping Protocol. In: R. Brohman, L. Bryant eds. *Existing Vegetation Classification and Mapping Technical Guide* (Gen. Tech. Rep. WO-67, 305). Washington, DC: U.S. Department of Agriculture, Forest Service, Ecosystem Management Coordination Staff.

Frescino, T. S., P. L. Patterson, E. A. Freeman, and G. G. Moisen. 2012. Using FIESTA, An R-Based Tool for Analysts, to Look at Temporal Trends in Forest Estimates. In R.S. Morin and G.C. Liknes, *Moving From Status to Trends: Forest Inventory and Analysis (FIA) Symposium 2012* (Gen. Tech. Rep. NRS-P-105, pp. 74-78). Baltimore, MD: U.S. Department of Agriculture, Forest Service, Northern Research Station.

Helms, J. A. (Ed.). 1998. *The Dictionary of Forestry*. Bethesda, MD: Society of American Foresters.

Huang, C., S. N. Goward, J. G. Masek, N. Thomas, Z. Zhu, and J. E. Vogelmann. 2010. An Automated Approach For Reconstructing Recent Forest Disturbance History Using Dense Landsat Time Series Stacks. *Remote Sensing of Environment, 114(1):* 183–198. doi:10.1016/j.rse.2009.08.017.

Mauk, R.L. and J.A. Henderson. 1984. Coniferous forest habitat types of northern Utah. GTR INT-170. USDA Forest Service, Intermountain Forest and Range Exp.Station. Ogden, UT. 89 p.

McGrath C.L., Woods A.J., Omernik, J.M., Bryce, S.A., Edmondson, M., Nesser, J.A., Shelden, J., Crawford, R.C., Comstock, J.A., and Plocher, M.D., 2002, Ecoregions of Idaho (color poster with map, descriptive text, summary tables, and photographs): Reston, Virginia, U.S. Geological Survey (map scale 1:1,350,000). Accessed: http://www.epa.gov/wed/pages/ecoregions/id_eco.htm

McNab, W.H.; Cleland, D.T.; Freeouf, J.A.; Keys, Jr., J.E.; Nowacki, G.J.; Carpenter, C.A., comps. 2005. Description of ecological subregions: sections of the conterminous United States. Washington, DC: U.S. Department of Agriculture, Forest Service. 80 p. Accessed: http://www.na.fs.fed.us/sustainability/ecomap/section_descriptions.pdf

Mueggler, W. F. 1988. *Aspen community types of the Intermountain Region* (GTR INT-250, 135 p.). Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station.

Nelson, M.L.; Brewer, C.K.; Solem, S.J., eds. 2015. Existing vegetation classification, mapping, and inventory technical guide, version 2.0. Gen. Tech. Rep. WO–90. Washington, DC: U.S. Department of Agriculture, Forest Service, Ecosystem Management Coordination Staff. 210 p.

Ruefenacht, B. 2014. *Review of DEM Derivatives for Vegetation Mapping* (RSAC-10078-RPT1, 19 p.). Salt Lake City, UT: U.S. Department of Agriculture, Forest Service, Remote Sensing Applications Center.

Ryherd, S., and C. Woodcock. 1996. Combining Spectral and Texture Data in the Segmentation of Remotely Sensed Images. *Photogrammetric Engineering & Remote Sensing, 62*(2), 181–194.

Steele, R., Pfister R.D., Ryker, R.A., Russell, A.R, and J.A. Kittams. 1981. Forest habitat types of central Idaho. GTR, INT-114. USDA Forest Service, Intermountain Forest and Range Exp.Station. Ogden, UT. 138 p.

Stehman, S. V., and R. L. Czaplewski. 1998. Design and Analysis for Thematic Map Accuracy Assessment: Fundamental Principles. *Remote Sensing of Environment. 64*, 331–344.

Story, M., and R. G. Congalton. 1986. Accuracy Assessment: A User's Perspective. *Photogrammetric Engineering and Remote Sensing. 52,* 397–399.

Tart, D., S. LaBrecque, D. Taylor, J. Shelly, R. Garwood, K. Fueling, B. Filbert, D. Skinner, T. Bandolin, D. Santini, and M. Anderson. 2015. *Sawtooth National Forest Draft Existing Vegetation Classification Keys*. U.S. Department of Agriculture, Forest Service, Region 4 Document. Retrieved from O:\NFS\R04\Collaboration\VCMQ\Sawtooth\VegClassExisting

Tuhy, J. 1981. Stream Bottom Community Classification for the Sawtooth Valley, Idaho. M.S. Thesis, University of Idaho. Moscow, ID. 230p.

Tuhy, J. and S. Jensen. 1982. Riparian Classification for the Upper Salmon/ Middle Fork Salmon Rivers, Idaho. White Horse Associates. Smithfield, UT. 200p. Unpub.

U.S. Department of Agriculture, Forest Service. 2013. *U.S. Department of Agriculture: Forest Service, Inventory, Monitoring, and Assessment Strategy*. Retrieved from https://ems-team.usda.gov/sites/fs-nrm-imac/Background%20Documents/FS%20IMA%20Strategy.pdf.

West, N. E., R. J. Tausch, and P. T. Tueller. 1998. *A Management-Oriented Classification of Pinyon-Juniper Woodlands of the Great Basin* (RMRS-GTR-12, 42 p.). Ogden, UT: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station.

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Appendices

Appendix A: Acquired Geospatial Data for Mapping

Geospatial Data	Source	Use
Landsat 5 TM – June 2009, July 2010 & 2011, August 2011, September 2010 & 2011	USGS GloVis	Modeling
NAIP 2011 (1-meter)	USDA Farm Service Agency	Modeling
Resource photography 2009 (0.5- meter)	Region 4 RO	Modeling & Segmentation
Digital Elevation Model (DEM)	i-cubed DataDoors	Modeling & Segmentation
Administrative boundary	Sawtooth NF	Identify project area
Land ownership	Sawtooth NF	Field site selection
Roads & trails	Sawtooth NF	Field site selection
Hydrology	Sawtooth NF	Field site selection
Landtype (Land Systems Inventory)	Sawtooth NF	Modeling
Fire severity & burn perimeters	MTBS	Modeling
Climate – average temperature	Daymet	Modeling
Climate – average humidity	Daymet	Modeling
Climate – frost days	Daymet	Modeling
Climate – growing days	Daymet	Modeling
Climate – heating degree days	Daymet	Modeling
Climate – total precipitation	Daymet	Modeling
Climate – frequency precipitation	Daymet	Modeling
IfSAR	Intermap Technologies	Size class modeling

Appendix B: Vegetation Indices, Transformations, and Topographic Derivatives

Geospatial Data	Source	Use
Landsat5 TM – NDVI	Erdas model	Modeling
Landsat5 TM – Principal Components (3)	Erdas model	Modeling
Landsat5 TM – Tasseled Cap	Erdas model	Modeling
VCT – Disturbance Detection	Customized model	Modeling
VCT – Disturbance Year	Customized model	Modeling
VCT – Disturbance Magnitude	Customized model	Modeling
NAIP 2011 – NDVI	Customized model	Modeling
Resource photography 2009 – NDVI	Customized model	Modeling & Segmentation
Heatload	Customized model	Modeling
Slope (degrees)	Customized model	Modeling
Slope-Aspect (Cos)	Customized model	Modeling
Slope-Aspect (Sin)	Customized model	Modeling
Surface-ground ratio	Customized model	Modeling
Heatload	Customized model	Modeling
Hillshade	Customized model	Modeling
Surface ground ratio	Customized model	Modeling
Valleybottom	Customized model	Modeling & Segmentation
Trishade	Customized model	Segmentation

Appendix C: Existing Vegetation Keys

Sawtooth National Forest DRAFT Existing Vegetation Classification Keys

7/21/2015

David Tart, Sharon LaBrecque, Debarah Taylor, John Shelly, Robin Garwood,
Karl Fueling, Bobbi Filbert, David Skinner, Tom Bandolin, Dena Santini, and Marisa Anderson

NOTE: These keys apply only to existing vegetation for mid-level mapping, not potential or historical vegetation.

R4 Key to Vegetation Formations

This key does not apply to lands used for agriculture or urban/residential development. It applies only to natural and semi-natural vegetation dominated by vascular plants. Semi-natural vegetation includes planted vegetation that is not actively managed or cultivated.

All cover values in this key to formations are absolute cover, not relative cover, for the life form. See Appendix A in this key for a discussion of absolute versus relative cover. In this key, tree cover includes both regeneration and overstory sized trees, so that young stands of trees are classified as forest.

First, identify the R4 Vegetation Formation of the plot, stand, or polygon using the key below. Vegetation Type Map Units (Map Unit) are defined in Appendix B.

			Key or D.T.	Map Unit
1a		All vascular plants total < 1% canopy cover……………………………………	**Non-Vegetated (p.15)**	
1b		All vascular plants total ≥ 1% canopy cover……………………………………	2	
	2a	All vascular plants total < 10% canopy cover………………………………..	**Sparse Veg.**	**BR/SV**
	2b	All vascular plants total ≥ 10% canopy cover………………………………..	3	
3a		Trees total ≥ 10% canopy cover………………………………………………	4	
3b		Trees total < 10% canopy cover………………………………………………	5	
	4a	Stand located above continuous forest line and trees stunted (< 5m tall) by harsh alpine growing conditions…………………………………………..	**Shrubland Key (p.4)**	
	4b	Stand not above continuous forest line; trees not stunted…………………	**Forest Key (p.2)**	
5a		Shrubs total ≥ 10% canopy cover……………………………………………	**Shrubland Key (p.4)**	
5b		Shrubs total < 10% canopy cover……………………………………………	6	
	6a	Herbaceous vascular plants total ≥ 10% canopy cover…………………….	7	
	6b	Herbaceous vascular plants total < 10% canopy cover…………………….	8	
7a		Total cover of graminoids ≥ total cover of forbs……………………………..	**Grassland Key (p.7)**	
7b		Total cover of graminoids < total cover of forbs……………………………..	**Forbland Key (p.11)**	
	8a	Trees total ≥ 5% canopy cover………………………………………………..	**Sparse Tree**	**BR/SV**
	8b	Trees total < 5% canopy cover………………………………………………..	9	
9a		Shrubs total ≥ 5% canopy cover………………………………………………	**Sparse Shrub**	**BR/SV**
9b		Shrubs total < 5% canopy cover………………………………………………	10	
	10a	Herbaceous vascular plants total ≥ 5% canopy cover……………………...	**Sparse Herb**	**BR/SV**
	10b	Herbaceous vascular plants total < 5% canopy cover……………………...	**Sparse Veg.**	**BR/SV**

Key to Forest and Woodland Dominance Types and DT Phases

Instructions:

1. Preferably, plots or polygons should be keyed out based on overstory canopy cover (trees forming the upper or uppermost canopy layer) by tree species.
2. Plots or polygons lacking such data or lacking an overstory layer should be keyed out using total cover by species.
3. If a plot or polygon does not key out using overstory cover, then it may be keyed using total tree cover.
4. If a tree species is not listed, then consult with the Regional Ecologist to assign a dominance type and map unit.
5. If two trees are equally abundant, the species encountered first in the key is recorded as the most abundant.
6. If Map Unit is 'n/a' (not applicable), then a sufficient number of field sites were not available to retain the dominance type as a map unit, and it was considered too ecologically distinct to combine with another map unit. Any available field data for the dominance type were still used for coarser level mapping as appropriate (e.g., conifer vs. other vegetation) and also for describing map unit composition.

			DT or DT Phase Code	Veg Type Map Unit	Veg Group
1a		Black cottonwood is the most abundant tree species………………..	**POBAT d.t.**	**RW**	**R**
1b		Black cottonwood is not the most abundant tree species…………..	**2**		
	2a	Sitka alder is the most abundant tree/shrub species…………………	**ALVIS d.t.**	**RW**	**R**
	2b	Sitka alder is not the most abundant tree/shrub species……………	**3**		
3a		Thinleaf alder is the most abundant tree/shrub species……………..	**ALINT d.t.**	**RW**	**R**
3b		Thinleaf alder is not the most abundant tree/shrub species………..	**4**		
	4a	Water birch is the most abundant tree/shrub species………………..	**BEOC2 d.t.**	**RW**	**R**
	4b	Water birch is not the most abundant tree/shrub species…………..	**5**		
5a		Quaking aspen is the most abundant tree species…………………..	**6**		
5b		Quaking aspen is not the most abundant tree species………………	**7**		
	6a	Conifer species total at least 10% absolute canopy cover…………..	**POTR5-Conifer d.t.p.**	**AS/C**	**D**
	6b	Conifer species total less than 10% absolute canopy cover………..	**POTR5-POTR5 d.t.p.**	**AS**	**D**
7a		Whitebark pine is the most abundant tree species…………………..	**PIAL d.t.**	**WBmix**	**C**
7b		Whitebark pine is not the most abundant tree species………………	**8**		
	8a	Limber pine is the most abundant tree species………………………	**PIFL2 d.t.**	**n/a**	**C**
	8b	Limber pine is not the most abundant tree species…………………..	**9**		
9a		Ponderosa pine is the most abundant tree species…………………	**10**		
9b		Ponderosa pine is not the most abundant tree species……………..	**11**		
	10a	Quaking aspen with at least 10% absolute canopy cover…………..	**PIPO-POTR5 d.t.p.**	**C/AS**	**D**
	10b	Quaking aspen with less than 10% absolute canopy cover…………	**PIPO-PIPO d.t.p.**	**PP**	**C**
11a		Lodgepole pine is the most abundant tree species…………………..	**12**		
11b		Lodgepole pine is not the most abundant tree species………………	**13**		
	12a	Quaking aspen with at least 10% absolute canopy cover…………..	**PICO-POTR5 d.t.p.**	**C/AS**	**D**
	12b	Quaking aspen with less than 10% absolute canopy cover…………	**PICO-PICO d.t.p.**	**LP**	**C**
13a		Douglas-fir is the most abundant species…………………………....	**14**		
13b		Douglas-fir is not the most abundant species………………………..	**17**		

			DT or DT Phase Code	Veg Type Map Unit	Veg Group
	14a	Quaking aspen with at least 10% absolute canopy cover…………..	**PSME-POTR5 d.t.p.**	**C/AS**	**D**
	14b	Quaking aspen with less than 10% absolute canopy cover………..	**15**		
15a		Ponderosa pine with at least 10% absolute canopy cover………….	**PSME-PIPO d.t.p.**	**DF**	**C**
15b		Ponderosa pine with less than 10% absolute canopy cover………..	**16**		
	16a	Lodgepole pine with at least 10% absolute canopy cover………….	**PSME-PICO d.t.p.**	**DFL**	**C**
	16b	Lodgepole pine with less than 10% absolute canopy cover………..	**PSME-PSME d.t.p.**	**DF**	**C**
17a		Engelmann spruce is the most abundant tree species………………	**PIEN d.t.**	**ES**	**C**
17b		Engelmann spruce is not the most abundant tree species………….	**18**		
	18a	Subalpine fir is the most abundant tree species………………………	**19**		
	18b	Subalpine fir is not the most abundant tree species………………….	**22**		
19a		Whitebark pine with at least 10% absolute canopy cover……………	**ABLA-PIAL d.t.p.**	**SAW**	**C**
19b		Whitebark pine with less than 10% absolute canopy cover…………	**20**		
	20a	Limber pine with at least 10% absolute canopy cover………………...	**ABLA-PIFL2 d.t.p.**	**SA**	**C**
	20b	Limber pine with less than 10% absolute canopy cover………………	**21**		
21a		Douglas-fir with at least 10% absolute canopy cover………………..	**ABLA-PSME d.t.p.**	**SAD**	**C**
21b		Douglas-fir with less than 10% absolute canopy cover………………	**ABLA-ABLA d.t.p.**	**SA**	**C**
	22a	Curlleaf mountain mahogany is the most abundant tree/shrub species………………………………………………………..	**CELE3 d.t.**	**MM**	**W**
	22b	Curlleaf mountain mahogany is not the most abundant tree/shrub species………………………………………………………..	**23**		
23a		Singleleaf pinyon is the most abundant tree/shrub species………..	**24**		
23b		Singleleaf pinyon is not the most abundant tree/shrub species……..	**25**		
	24a	Utah juniper provides less than 20% of the total tree cover…………..	**PIMO-PIMO d.t.p.**	**PJ**	**W**
	24b	Utah juniper provides ≥20% of the total tree cover………..………..	**PIMO-JUOS d.t.p.**	**PJ**	**W**
25a		Rocky Mountain juniper is the most abundant tree/shrub species…...	**JUSC2 d.t.**	**Jmix**	**W**
25b		Rocky Mountain juniper is not the most abundant tree/shrub species	**26**		
	26a	Utah juniper is the most abundant tree/shrub species………………	**27**		
	26b	Utah juniper is not the most abundant tree/shrub species…………..	**28**		
27a		Singleleaf pinyon provides ≥20% of the total tree cover………………	**JUOS-PIMO d.t.p.**	**Jmix**	**W**
27b		Singleleaf pinyon provides less than 20% of the total tree cover…….	**JUOS d.t.**	**Jmix**	**W**
	28a	Bigtooth maple is the most abundant tree/shrub species……………..	**ACGR3 d.t.**	**n/a**	**W**
	28b	Bigtooth maple is not the most abundant tree/shrub species………..	**29**		
29a		Another or an unknown conifer is the most abundant tree species…	**UNKNOWN**	**UNK**	**C**
29b		The most abundant tree species is a broadleaf ……………………..	**30**		
	30a	Stand is located in a riparian setting as indicated by proximity to a stream or lake, topographic position, plant species that require or tolerate free or unbound water, and/or soil properties associated with seasonally high water tables……………………………………………………………	**UNDEFINED**	**RW**	**R**
	30b	Stand not located in a riparian setting as described above….	**UNDEFINED**	**UND**	**D**

Key to Shrubland Dominance Types

Instructions:

Plots or polygons should be keyed out based on total cover by species. This key is divided into riparian, alpine, and upland sections. First, identify the physical setting of the plot, stand, or polygon using the key below.

For the purposes of this key, a riparian setting is defined as an area (typically transitional between aquatic and terrestrial ecosystems) identified by soil characteristics associated with at least seasonally high water tables, distinctive vegetation that requires or tolerates free or unbound water (Manning and Padgett 1995), proximity to a stream or lake, and/or topographic position (e.g., valley bottom). The alpine setting includes the area above the upper limit of continuous forest. Above this limit, trees occur only in scattered patches and become increasingly stunted at higher elevations (Arno and Hammerly 1984). In this key, the alpine setting takes precedence over the riparian setting. The upland setting includes non-riparian areas below the continuous forest line.

It is likely that some dominance types occur in more than one of these settings. If your plot does not key out successfully in one setting, then try another setting. For example, basin big sagebrush is in the upland key but may occur in degraded riparian areas with downcut streams.

Key to Physical Habitat Setting

Key Leads:

1a		Stand is located in an alpine setting above the upper elevation limit of continuous forest……………………………………………………………………	**Go to Alpine Key (p.4)**
1b		Stand is located below the upper elevation limit of continuous forest…………..	**2**
	2a	Stand is located in a riparian setting as indicated by proximity to a stream or lake, topographic position, plant species that require or tolerate free or unbound water, and/or soil properties associated with seasonally high water tables………………………………………………………………………………	**Go to Riparian Key (p.5)**
	2b	Stand not located in a riparian setting as described above……………………….	**Go to Upland Key (p.6)**

Key to Alpine Shrubland Dominance Types

Instructions:

1. Codes for dominance type and map unit can be found using Table 1. Find the name of the most abundant shrub in column 2 and move to column 3 for the dominance type code, column 4 for the map unit code, and column 5 for the map group code.
2. When two or more shrub species are equal in abundance, the species listed first in Table 1 is used to assign the dominance type and map unit.
3. If the most abundant shrub species is not listed in Table 1, then consult with the Regional Ecologist to assign a dominance type.

Table 1: Most Abundant Alpine Shrub and Indicated Dominance Type and Veg. Type Map Unit

(1) Rank	(2) Most Abundant Graminoid (Dominance Type)		(3) Dom. Type Code	(4) Veg Type Map Unit	(5) Veg Group
1	*Salix nivalis*	snow willow	SANI8	**ALP**	**A**
2	*Phyllodoce empetriformis*	pink mountainheath	PHEM	**ALP**	**A**
3	*Cassiope mertensiana*	western moss heather	CAME7	**ALP**	**A**
4	*Vaccinium cespitosum*	dwarf bilberry	VACE-A	**ALP**	**A**
5	*Vaccinium scoparium*	grouse whortleberry	VASC-A	**ALP**	**A**
6	*Ribes montigenum*	gooseberry currant	RIMO2-A	**ALP**	**A**
7	*Ericameria suffruticosa*	singlehead goldenbush	ERSU13-A	**ALP**	**A**

8	*Artemisia arbuscula*	low sagebrush	ARAR8	**DSB**	**S**
	Species not listed above		See Instruction 3 above	**ALP**	**A**
	Species unidentifiable		UNKNOWN	**ALP**	**A**

Key to Riparian Shrubland Dominance Types

Instructions:

1. Plots or polygons should be keyed out based on total cover by species.
2. Codes for dominance type and map unit can be found using Table 2. Find the name of the most abundant shrub in column 2 and move to column 3 for the dominance type code, column 4 for the map unit code, and column 5 for the map group code.
3. When two or more shrub species are equal in abundance, the species listed first in Table 2 is used to assign the dominance type and map unit.
4. If the most abundant shrub species is not listed in Table 2, then consult with the Regional Ecologist to assign a dominance type.

Table 2: Most Abundant Riparian Shrub and Indicated Dominance Type and Veg. Type Map Unit

(1) Rank	(2) Most Abundant Shrub (Dominance Type)		(3) Dom. Type Code	(4) Veg Type Map Unit	(5) Veg Group
1	*Alnus viridis* ssp. *sinuata*	Sitka alder	ALVIS	**RW**	**R**
2	*Alnus incana* ssp. *tenuifolia*	thinleaf alder	ALINT	**RW**	**R**
3	*Betula occidentalis*	water birch	BEOC2	**RW**	**R**
4	*Salix brachycarpa*	shortfruit willow	SABR	**RW**	**R**
5	*Salix boothii*	Booth's willow	SABO2	**RW**	**R**
6	*Salix drummondiana*	Drummond's willow	SADR	**RW**	**R**
7	*Salix monticola*	park willow	SAMO2	**RW**	**R**
8	*Salix geyeriana*	Geyer's willow	SAGE2	**RW**	**R**
9	*Salix lemmonii*	Lemmon's willow	SALE	**RW**	**R**
10	*Salix exigua*	coyote willow	SAEX	**RW**	**R**
11	*Salix lutea*	yellow willow	SALU2	**RW**	**R**
12	*Salix lucida* ssp. *lasiandra*	whiplash willow	SALUL	**RW**	**R**
13	*Salix bebbiana*	Bebb willow	SABE2	**RW**	**R**
14	*Salix wolfii*	Wolf's willow	SAWO	**RW**	**R**
15	*Betula glandulosa*	resin birch	BEGL	**RW**	**R**
16	*Betula pumilis*	bog birch	BEPU4	**RW**	**R**
17	*Betula nana*	dwarf birch	BENA	**RW**	**R**
18	*Salix planifolia*	planeleaf willow	SAPL2	**RW**	**R**
19	*Salix glauca*	grayleaf willow	SAGL	**RW**	**R**
20	*Vaccinium uglinosum*	bog blueberry	VAUL	**RW**	**R**
21	*Spiraea douglasii*	rose spirea	SPDO	**RW**	**R**
22	*Cornus sericea*	redosier dogwood	COSE16	**RW**	**R**
23	*Crataegus douglasii*	black hawthorn	CRDO2	**RW**	**R**
24	*Ribes hudsonianum*	northern black currant	RIHU	**RW**	**R**
25	*Philadelphus lewisii*	Lewis' mockorange	PHLE4	**RW**	**R**
26	*Rhamnus alnifolia*	alderleaf buckthorn	RHAL	**RW**	**R**
27	*Salix scouleriana*	Scouler willow	SASC-R	**RW**	**R**
28	*Dasiphora fruticosa*	shrubby cinquefoil	DAFR6	**RW**	**R**
29	*Artemisia cana* ssp. *viscidula*	mountain silver sagebrush	ARCAV2	**RW**	**R**
	Species not listed above		See Instruction 4 above	**RW**	**R**
	Species unidentifiable		UNKNOWN	**RW**	**R**

Key to Upland Shrubland Dominance Types

Instructions:

1. Plots or polygons should be keyed out based on total cover by species.
2. Codes for dominance type and map unit can be found using Table 3. Find the name of the most abundant shrub in column 2 and move to column 3 for the dominance type code, column 4 for the map unit code, and column 5 for the map group code.
3. When two or more shrub species are equal in abundance, the species listed first in Table 3 is used to assign the dominance type and map unit.
4. If the most abundant shrub species is not listed in Table 3, then consult with the Regional Ecologist to assign a dominance type and map unit.

5. If Map Unit is ‘n/a’ (not applicable), then a sufficient number of field sites were not available to retain the dominance type as a map unit, and it was considered too ecologically distinct to combine with another map unit. Any available field data for the dominance type were still used for coarser level mapping as appropriate (e.g., conifer vs. other vegetation) and also for describing map unit composition.

Table 3: Most Abundant Upland Shrub and Indicated Dominance Type and Veg. Type Map Unit

(1) Rank	(2) Most Abundant Shrub (Dominance Type)		(3) Dom. Type Code	(4) Veg Type Map Unit	(5) Veg Group
1	*Ledum glandulosum*	Labrador tea	LEGL	**FS**	**S**
2	*Vaccinium cespitosum*	dwarf bilberry	VACE-U	**FS**	**S**
3	*Vaccinium scoparium*	grouse whortleberry	VASC-U	**FS**	**S**
4	*Vaccinium membranaceum*	thinleaf huckleberry	VAME	**FS**	**S**
5	*Physocarpus malvaceus*	mallow ninebark	PHMA5	**FS**	**S**
6	*Acer glabrum*	Rocky Mountain maple	ACGL	**FS**	**S**
7	*Rubus parviflorus*	thimbleberry	RUPA	**FS**	**S**
8	*Ribes montigenum*	gooseberry currant	RIMO2-U	**FS**	**S**
9	*Shepherdia canadensis*	russet buffaloberry	SHCA	**FS**	**S**
10	*Sambucus racemosa*	red elderberry	SARA2	**FS**	**S**
11	*Sambucus nigra* ssp. *cerulea*	blue elderberry	SANIC5	**FS**	**S**
12	*Salix scouleriana*	Scouler willow	SASC-U	**FS**	**S**
13	*Spiraea betulifolia*	White spiraea	SPBE2	**FS**	**S**
14	*Symphoricarpos albus*	common snowberry	SYAL	**FS**	**S**
15	*Holodiscus discolor*	oceanspray	HODI	**FS**	**S**
16	*Ribes lacustre*	prickly currant	RILA	**FS**	**S**
17	*Mahonia repens*	creeping barberry	MARE11	**FS**	**S**
18	*Ribes viscosissimum*	sticky currant	RIVI3	**FS**	**S**
19	*Ceanothus velutinus*	snowbrush ceanothus	CEVE	**FS**	**S**
20	*Arctostaphylos uva-ursi*	kinnikinnick	ARUV	**FS**	**S**
21	*Amelanchier utahensis*	Utah serviceberry	AMUT	**MS**	**S**
22	*Amelanchier alnifolia*	Saskatoon serviceberry	AMAL2	**MS**	**S**
23	*Prunus virginiana*	common chokecherry	PRVI	**MS**	**S**
24	*Rosa woodsii*	Wood’s rose	ROWO	**MS**	**S**
25	*Prunus emarginata*	bitter cherry	PREM	**MS**	**S**
26	*Symphoricarpos oreophilus*	mountain snowberry	SYOR2	**MS**	**S**
27	*Ribes cereum*	wax currant	RICE	**MS**	**S**
28	*Rhus glabra*	smooth sumac	RHGL	**MS**	**S**
29	*Purshia tridentata*	bitterbrush	PUTR2	**BB**	**S**
30	*Artemisia spiciformis*	snowfield sagebrush	ARSP8	**MSB**	**S**
31	*Artemisia tridentata* ssp. *vaseyana*	mountain big sagebrush	ARTRV	**MSB**	**S**
32	*Artemisia tridentata* ssp. *tridentata*	basin big sagebrush	ARTRT	**WSB**	**S**
33	*Artemisia trid.* ssp. *wyomingensis*	Wyoming big sagebrush	ARTRW8	**WSB**	**S**
34	*Chrysothamnus viscidiflorus*	yellow rabbitbrush	CHVI8	**n/a**	**S**
35	*Ericameria nauseosa*	rubber rabbitbrush	ERNA10	**n/a**	**S**

36	*Ericameria suffruticosa*	singlehead goldenbush	ERSU13-U	**MSB**	**S**
37	*Artemisia frigida*	prairie sagewort	ARFR4	**MSB**	**S**
38	*Artemisia rigida*	stiff sagebrush	ARRI2	**DSB**	**S**
39	*Artemisia arbuscula* ssp. *thermopola*	cleftleaf sagebrush	ARART	**DSB**	**S**
40	*Artemisia arbuscula* ssp. *longiloba*	early sagebrush	ARARL	**DSB**	**S**
41	*Artemisia arbuscula* ssp. *arbuscula*	low sagebrush	ARARA	**DSB**	**S**
42	*Artemisia nova*	black sagebrush	ARNO4	**DSB**	**S**
43	*Eriognum douglasii*	Douglas' buckwheat	ERDO	**DSB**	**S**
	Species not listed above		See Instruction 4 above		**S**
	Species unidentifiable		UNKNOWN		**S**

Key to Grassland Dominance Types

Instructions:

Plots or polygons should be keyed out based on total cover by species. This key is divided into riparian, alpine, and upland sections. First, identify the physical setting of the plot, stand, or polygon using the key below.

For the purposes of this key, a riparian setting is defined as an area (typically transitional between aquatic and terrestrial ecosystems) identified by soil characteristics associated with at least seasonally high water tables, distinctive vegetation that requires or tolerates free or unbound water (Manning and Padgett 1995), proximity to a stream or lake, and/or topographic position (e.g., valley bottom). The alpine setting includes the area above the upper limit of continuous forest. Above this limit trees occur only in scattered patches and become increasingly stunted at higher elevations (Arno and Hammerly 1984). In this key, the alpine setting takes precedence over the riparian setting. The upland setting includes non-riparian areas below the continuous forest line.

It is likely that some dominance types occur in more than one of these settings. If your plot does not key out successfully in one setting, then try another setting. For example, tufted hairgrass is in the riparian herbland key but also is found in the alpine and riparian herbland keys.

Key to Physical Habitat Setting

Key Leads:

1a	Stand is located in an alpine setting above the upper elevation limit of continuous forest……	**Go to Alpine Key (p.8)**
1b	Stand is located below the upper elevation limit of continuous forest……	**2**
2a	Stand is located in a riparian setting as indicated by proximity to a stream or lake, topographic position, plant species that require or tolerate free or unbound water, and/or soil properties associated with seasonally high water tables……	**Go to Riparian Key (p.9)**
2b	Stand not located in a riparian setting as described above……	**Go to Upland Key (p.10)**

Key to Alpine Grassland Dominance Types

Instructions:

1. Codes for dominance type and map unit can be found using Table 4. Find the name of the most abundant species in column 2 and move to column 3 for the dominance type code, column 4 for the map unit code, and column 5 for the map group code.
2. When two or more species are equal in abundance, the species listed first in Table 4 is used to assign the dominance type and map unit.
3. If the most abundant species is not listed in Table 4, then consult with the Regional Ecologist to assign a dominance type.

Table 4: Most Abundant Alpine Graminoid and Indicated Dominance Type and Veg. Type Map Unit

(1) Rank	(2) Most Abundant Graminoid (Dominance Type)		(3) Dom. Type Code	(4) Veg Type Map Unit	(5) Veg Group
1	*Juncus parryi*	Parry's rush	JUPA	**ALP**	**A**
2	*Juncus drummondii*	Drummond's rush	JUDR	**ALP**	**A**
3	*Carex engelmannii*	Engelmann's sedge	CAEN3	**ALP**	**A**
4	*Carex elynoides*	blackroot sedge	CAEL3	**ALP**	**A**
5	*Deschampsia cespitosa*	tufted hairgrass	DECE-A	**ALP**	**A**
6	*Phleum alpinum*	alpine timothy	PHAL2	**ALP**	**A**
7	*Danthonia intermedia*	timber oatgrass	DAIN-A	**ALP**	**A**
8	*Festuca brachyphylla*	alpine fescue	FEBR	**ALP**	**A**
9	*Elymus scribneri*	spreading wheatgrass	ELSC4	**ALP**	**A**
10	*Trisetum spicatum*	spike trisetum	TRSP2	**ALP**	**A**
11	*Carex geyeri*	elk sedge	CAGE2-A	**ALP**	**A**
12	*Carex rossii*	Ross' sedge	CARO5-A	**ALP**	**A**
13	*Festuca idahoensis*	Idaho fescue	FEID-A	**ALP**	**A**
14	*Elymus elymoides*	squirreltail	ELEL5-A	**ALP**	**A**
	Species not listed above		See Instruction 3 above	**ALP**	**A**
	Species unidentifiable		UNKNOWN	**ALP**	**A**

Key to Riparian Grassland Dominance Types

Instructions:

1. Codes for dominance type and map unit can be found using Table 5. Find the name of the most abundant graminoid in column 2 and move to column 3 for the dominance type code, column 4 for the map unit code, and column 5 for the map group code.
2. When two or more graminoid species are equal in abundance, the species listed first in Table 5 is used to assign the dominance type and map unit.
3. If the most abundant graminoid species is not listed in Table 5, then consult with the Regional Ecologist to assign a dominance type.

Table 5: Most Abundant Riparian Graminoid and Indicated Dominance Type and Veg. Type Map Unit

(1) Rank	(2) Most Abundant Graminoid (Dominance Type)		(3) Dom. Type Code	(4) Veg Type Map Unit	(5) Veg Group
1	*Trichophorum cespitosum*	tufted bulrush	TRCE3	**RHE**	**R**
2	*Schoenplectus americanus*	chairmaker's bulrush	SCAM6	**RHE**	**R**
3	*Scirpus microcarpus*	small-fruit bulrush	SCMI2	**RHE**	**R**
4	*Carex simulata*	analogue sedge	CASI2	**RHE**	**R**
5	*Eleocharis quinqueflora*	fewflower spikerush	ELQU2	**RHE**	**R**
6	*Eleocharis rostellata*	beaked spikeruch	ELRO2	**RHE**	**R**
7	*Carex livida*	livid sedge	CALI	**RHE**	**R**
8	*Carex buxbaumii*	Buxbaum's sedge	CABU6	**RHE**	**R**
9	*Carex saxatilis*	rock sedge	CASA10	**RHE**	**R**
10	*Carex aquatlis*	water sedge	CAAQ	**RHE**	**R**
11	*Carex utriculata*	NW Territory sedge	CAUT	**RHE**	**R**
12	*Carex cusickii*	Cusick's sedge	CACU5	**RHE**	**R**
13	*Catabrosa aquatic*	water whorlgrass	CAAQ3	**RHE**	**R**
14	*Calamagrostis canadensis*	bluejoint reedgrass	CACA4	**RHE**	**R**
15	*Carex nebrascensis*	Nebraska sedge	CANE2	**RHE**	**R**
16	*Carex pellita*	woolly sedge	CAPE42	**RHE**	**R**
17	*Agrostis scabra*	rough bentgrass	AGSC5	**RHE**	**R**
18	*Carex athrostachya*	slenderbeak sedge	CAAT3	**RHE**	**R**
19	*Muhlenbergia filiformis*	pullup muhly	MUFI2	**RHE**	**R**
20	*Deschampsia cespitosa*	tufted hairgrass	DECE-R	**RHE**	**R**
21	*Danthonia intermedia*	timber oatgrass	DAIN-R	**RHE**	**R**
22	*Carex microptera*	smallwing sedge	CAMI7	**RHE**	**R**
23	*Carex spectabilis*	showy sedge	CASP5	**RHE**	**R**
24	*Agrostis exarata*	Spike bentgrass	AGEX	**RHE**	**R**
25	*Carex praegracilis*	clustered field sedge	CAPR5	**RHE**	**R**
26	*Muhlenbergia richardsonis*	mat muhly	MURI	**RHE**	**R**
27	*Poa secunda* ssp. *juncifolia*	Nevada bluegrass	POSEJ	**RHE**	**R**
28	*Juncus arcticus* ssp. *littoralis*	mountain rush	JUARL	**RHE**	**R**
29	*Carex praeceptorum*	early sedge	CAPR4	**RHE**	**R**
30	*Carex praticola*	meadow sedge	CAPR7	**RHE**	**R**
31	*Bromus ciliatus*	fringed brome	BRCI2	**RHE**	**R**
32	*Hordeum brachyantherum*	meadow barley	HOBR2	**RHE**	**R**
33	*Alopecurus pratensis*	meadow foxtail	ALPR3	**RHE**	**R**
34	*Leymus cinereus*	basin wildrye	LECI4-R	**RHE**	**R**
35	*Festuca rubra*	Red fescue	FERU2	**RHE**	**R**
36	*Poa pratensis*	Kentucky bluegrass	POPR	**RHE**	**R**
	Species not listed above		See Instruction 3 above	**RHE**	**R**
	Species unidentifiable		UNKNOWN	**RHE**	**R**

Key to Upland Grassland Dominance Types

Instructions:

1. Codes for dominance type and map unit can be found using Table 6. Find the name of the most abundant graminoid in column 2 and move to column 3 for the dominance type code, column 4 for the map unit code, and column 5 for the map group code.
2. When two or more graminoid species are equal in abundance, the species listed first in Table 6 is used to assign the dominance type and map unit.
3. If the most abundant graminoid species is not listed in Table 6, then consult with the Regional Ecologist to assign a dominance type.

Table 6: Most Abundant Upland Graminoid and Indicated Dominance Type and Veg. Type Map Unit

(1) Rank	(2) Most Abundant Graminoid (Dominance Type)		(3) Dom. Type Code	(4) Veg Type Map Unit	(5) Veg Group
1	*Luzula glabrata (hitchcockii)*	smooth woodrush	LUGL2	**GR**	**H**
2	*Calamagrostis rubescens*	pinegrass	CARU	**GR**	**H**
3	*Carex geyeri*	elk sedge	CAGE2-U	**GR**	**H**
4	*Carex rossii*	Ross' sedge	CARO5-U	**GR**	**H**
5	*Trisetum canescens*	tall trisetum	TRCA21	**GR**	**H**
6	*Bromus marginatus*	mountain brome	BRMA4	**GR**	**H**
7	*Poa wheeleri*	Wheeler's bluegrass	POWH2	**GR**	**H**
8	*Melica bulbosa*	oniongrass	MEBU	**GR**	**H**
9	*Carex hoodii*	Hood's sedge	CAHO5	**GR**	**H**
10	*Leucopoa kingii*	spike fescue	LEKI2	**GR**	**H**
11	*Elymus trachycaulus*	slender wheatgrass	ELTR7	**GR**	**H**
12	*Festuca idahoensis*	Idaho fescue	FEID-U	**GR**	**H**
13	*Koleria macrantha*	prairie Junegrass	KOMA	**GR**	**H**
14	*Achnatherum (Stipa) occidentale*	western needlegrass	ACOC3	**GR**	**H**
15	*Achnatherum nelsonii*	Columbia needlegrass	ACNE9	**GR**	**H**
16	*Achnatherum lettermanii*	Letterman's needlegrass	ACLE9	**GR**	**H**
17	*Carex pachystachya*	chamisso sedge	CAPA14	**GR**	**H**
18	*Leymus cinereus*	basin wildrye	LECI4-U	**GR**	**H**
19	*Pseudoroegneria (Agropyron) spicata*	bluebunch wheatgass	PSSP6	**GR**	**H**
20	*Achnatherum (Stipa) thurberianum*	Thurber's needlegrass	ACTH7	**GR**	**H**
21	*Hespirostipa comate*	needle-and-thread	HECO26	**GR**	**H**
22	*Achnatherum hymenoides*	Indian ricegrass	ACHY	**GR**	**H**
23	*Elymus elymoides*	bottlebrush squirreltail	ELEL5-U	**GR**	**H**
24	*Poa secunda* ssp. *secunda*	Sandberg's bluegrass	POSES6	**GR**	**H**
25	*Poa compressa*	Canada bluegrass	POCO	**GR**	**H**
26	*Dactylis glomerata*	orchardgrass	DAGL	**GR**	**H**
27	*Bromus inermis*	smooth brome	BRIN2	**GR**	**H**
28	*Thinopyrum (Agropyron) intermedium*	intermediate wheatgrass	THIN6	**GR**	**H**
29	*Bromus tectorum*	cheatgrass	BRTE	**GR**	**H**
30	*Poa bulbosa*	bulbous bluegrass	POBU	**GR**	**H**
	Species not listed above		See Instruction 3 above	**GR**	**H**
	Species unidentifiable		UNKNOWN	**GR**	**H**

Key to Forbland Dominance Types

Instructions:

Plots or polygons should be keyed out based on total cover by species. This key is divided into riparian, alpine, and upland sections. First, identify the physical setting of the plot, stand, or polygon using the key below.

For the purposes of this key, a riparian setting is defined as an area (typically transitional between aquatic and terrestrial ecosystems) identified by soil characteristics associated with at least seasonally high water tables, distinctive vegetation that requires or tolerates free or unbound water (Manning and Padgett 1995), proximity to a stream or lake, and/or topographic position (e.g., valley bottom). The alpine setting includes the area above the upper limit of continuous forest. Above this limit, trees occur only in scattered patches and become increasingly stunted at higher elevations (Arno and Hammerly 1984). In this key, the alpine setting takes precedence over the riparian setting. The upland setting includes non-riparian areas below the continuous forest line.

It is likely that some dominance types occur in more than one of these settings. If your plot does not key out successfully in one setting, then try another setting. For example, basin big sagebrush is in the upland key but may occur in degraded riparian areas with downcut streams.

Key to Physical Habitat Setting

Key Leads:

1a	Stand is located in an alpine setting above the upper elevation limit of continuous forest……………………………………………………………………	**Go to Alpine Key (p.12)**
1b	Stand is located below the upper elevation limit of continuous forest……………	**2**
2a	Stand is located in a riparian setting as indicated by proximity to a stream or lake, topographic position, plant species that require or tolerate free or unbound water, and/or soil properties associated with seasonally high water tables………………………………………………………………………………	**Go to Riparian Key (p.13)**
2b	Stand not located in a riparian setting as described above……………………….	**Go to Upland Key (p.14)**

Key to Alpine Forbland Dominance Types

Instructions:

1. Codes for dominance type and map unit can be found using Table 7. Find the name of the most abundant forb in column 2 and move to column 3 for the dominance type code, column 4 for the map unit code, and column 5 for the map group code.
2. When two or more forb species are equal in abundance, the species listed first in Table 7 is used to assign the dominance type and map unit.
3. If the most abundant forb species is not listed in Table 7, then consult with the Regional Ecologist to assign a dominance type.

Table 7: Most Abundant Alpine Forb and Indicated Dominance Type and Veg. Type Map Unit

(1) Rank	(2) Most Abundant Forb (Dominance Type)		(3) Dom. Type Code	(4) Veg Type Map Unit	(5) Veg Group
1	*Geum rossii*	Ross' avens	GERO2	**ALP**	**A**
2	*Potentilla diversifolia*	varileaf cinquefoil	PODI2	**ALP**	**A**
3	*Sibbaldia procumbens*	creeping sibbaldia	SIPR	**ALP**	**A**
4	*Ligusticum canbyi*	Canby's licorice-root	LICA2	**ALP**	**A**
5	*Arenaria aculeata*	prickly sandwort	ARAC2	**ALP**	**A**
6	*Phlox pulvinata*	cushion phlox	PHPU5	**ALP**	**A**
7	*Phlox diffusa*	spreading phlox	PHDI3	**ALP**	**A**
8	*Ivesia gordonii*	Gordon's ivesia	IVGO	**ALP**	**A**
9	*Polygonum phytolaccifolium*	poke knotweed	POPH-A	**ALP**	**A**
10	*Draba oligosperum*	fewseed draba	DROL	**ALP**	**A**
11	*Eriogonum flavum*	alpine golden buckwheat	ERFL4	**ALP**	**A**
12	*Eriogonum ovalifolium*	cushion buckwheat	EROV	**ALP**	**A**
13	*Eriogonum caepitosum*	matted buckwheat	ERCA8	**ALP**	**A**
14	*Eriophyllum lanatum*	common woolly sunflower	ERLA6	**ALP**	**A**
15	*Agoseris glauca*	pale agoseris	AGGL	**ALP**	**A**
	Species not listed above		See Instruction 3 above	**ALP**	**A**
	Species unidentifiable		UNKNOWN	**ALP**	**A**

Key to Riparian Forbland Dominance Types

Instructions:

1. Codes for dominance type and map unit can be found using Table 8. Find the name of the most abundant forb in column 2 and move to column 3 for the dominance type code, column 4 for the map unit code, and column 5 for the map group code.
2. When two or more forb species are equal in abundance, the species listed first in Table 8 is used to assign the dominance type and map unit.
3. If the most abundant forb species is not listed in Table 8, then consult with the Regional Ecologist to assign a dominance type.

Table 8: Most Abundant Riparian Forb and Indicated Dominance Type and Veg. Type Map Unit

(1) Rank	(2) Most Abundant Forb (Dominance Type)		(3) Dom. Type Code	(4) Veg Type Map Unit	(5) Veg Group
1	*Nuphar lutea* ssp. *polysepala*	Rocky Mountain pond-lily	NULUP	**RHE**	**R**
2	*Sparganium angustifolium*	narrowleaf bur-reed	SPAN2	**RHE**	**R**
3	*Equisetum arvense*	field horsetail	EQAR	**RHE**	**R**
4	*Polemonium occidentale*	western polemonium	POOC2	**RHE**	**R**
5	*Nasturtium officinale*	Watercress	NAOF	**RHE**	**R**
6	*Senecio triangularis*	arrowleaf ragwort	SETR	**RHE**	**R**
7	*Mertensia ciliata*	tall fringed bluebells	MECI3	**RHE**	**R**
8	*Dodecathion jeffreyi*	Sierra shootingstar	DOJE	**RHE**	**R**
9	*Camassia quamash*	small camas	CAQU2	**RHE**	**R**
10	*Camassia cusickii*	Cusick's camas	CACU2	**RHE**	**R**
11	*Maianthemum stellatum*	starry false lily of the valley	MAST4	**RHE**	**R**
12	*Aconitum columbianum*	Columbian monkshood	ACCO4	**RHE**	**R**
13	*Mertensia campanulata*	Idaho bluebells	MECA6	**RHE**	**R**
14	*Mimulus guttatus*	seep monkeyflower	MIGU	**RHE**	**R**
15	*Thalictrum alpinum*	alpine meadow-rue	THAL	**RHE**	**R**
16	*Arnica chamissonis*	Chamisso arnica	ARCH3	**RHE**	**R**
17	*Veratrum californicum*	California false hellebore	VECA2	**RHE**	**R**
18	*Castilleja miniata*	giant red Indian paintbrush	CAMI12	**RHE**	**R**
19	*Rudbeckia occidentlis*	western coneflower	RUOC2-R	**RHE**	**R**
20	*Solidago canadensis*	Canada goldenrod	SOCA6	**RHE**	**R**
21	*Cirsium arvense*	Canada thistle	CIAR4-R	**RHE**	**R**
22	*Potentilla gracilis*	slender cinquefoil	POGR9-R	**RHE**	**R**
23	*Senecio sphaerocephalus*	ballhead ragwort	SESP4	**RHE**	**R**
24	*Symphyotrichum foliaceum*	leafy aster	SYFO2-R	**RHE**	**R**
25	*Achillea millefolium*	common yarrow	ACMI2-R	**RHE**	**R**
26	*Epilobium ciliatum*	fringed willowherb	EPCI	**RHE**	**R**
27	*Penstemon attenuatus*	sulphur penstemon	PEAT3-R	**RHE**	**R**
28	*Penstemon globosus*	globe penstemon	PEGL5	**RHE**	**R**
29	*Zigadenus elegans*	mountain deathcamas	ZIEL2	**RHE**	**R**
30	*Taraxacom officinale*	common dandelion	TAOF-R	**RHE**	**R**
	Species not listed above		See Instruction 3 above	**RHE**	**R**
	Species unidentifiable		UNKNOWN	**RHE**	**R**

Key to Upland Forbland Dominance Types

Instructions:

1. Codes for dominance type and map unit can be found using Table 9. Find the name of the most abundant forb in column 2 and move to column 3 for the dominance type code, column 4 for the map unit code, and column 5 for the map group code.
2. When two or more forb species are equal in abundance, the species listed first in Table 9 is used to assign the dominance type and map unit.
3. If the most abundant forb species is not listed in Table 9, then consult with the Regional Ecologist to assign a dominance type.

Table 9: Most Abundant Upland Forb and Indicated Dominance Type and Veg. Type Map Unit

(1) Rank	(2) Most Abundant Forb (Dominance Type)		(3) Dom. Type Code	(4) Veg Type Map Unit	(5) Veg Group
1	*Senecio serra*	tall ragwort	SESE2	**FO**	**H**
2	*Balsamorhiza sagittata*	arrowleaf balsamroot	BASA3	**FO**	**H**
3	*Helianthella uniflora*	oneflower helianthella	HEUN	**FO**	**H**
4	*Geranium viscosissimum*	sticky geranium	GEVI2	**FO**	**H**
5	*Solidago multiradiata*	Rocky Mtn. goldenrod	SOMU	**FO**	**H**
6	*Pteryxia terebinthina*	turpentine wavewing	PTTE	**FO**	**H**
7	*Penstemon attenuatus*	sulphur penstemon	PEAT3-U	**FO**	**H**
8	*Chamerion angustifolium*	fireweed	CHAN9	**FO**	**H**
9	*Illiamna rivularis*	streambank wild hollyhock	ILRI	**FO**	**H**
10	*Rudbeckia occidentalis*	western coneflower	RUOC2-U	**FO**	**H**
11	*Wyethia amplexicaulis*	mule-ears	WYAM	**FO**	**H**
12	*Wyethia helianthoides*	sunflower mule-ears	WYHE2	**FO**	**H**
13	*Eurybia (Aster) integrifolia*	thickstem aster	EUIN9	**FO**	**H**
14	*Arnica amplexicaulis*	clasping arnica	ARAM2	**FO**	**H**
15	*Hackelia micrantha*	Jessica sticktight	HAMI	**FO**	**H**
16	*Pyrrocoma uniflora*	plantain goldenweed	PYUN2	**FO**	**H**
17	*Valeriana sitchensis*	Sitka valerian	VASI	**FO**	**H**
18	*Polemonium pulcherrimum*	Jacob's-ladder	POPU3	**FO**	**H**
19	*Thalictrum occidentale*	western meadow-rue	THOC	**FO**	**H**
20	*Pteridium aquilinum*	western brackenfern	PTAQ	**FO**	**H**
21	*Polygonum phytolaccifolium*	poke knotweed	POPH-U	**FO**	**H**
22	*Potentilla glandulosa*	sticky cinquefoil	POGL9-U	**FO**	**H**
23	*Apocynum androsaemifolium*	spreading dogbane	APAN2	**FO**	**H**
24	*Arnica cordifolia*	heartleaf arnica	ARCO9	**FO**	**H**
25	*Potentilla gracilis*	slender cinquefoil	POGR9-U	**FO**	**H**
26	*Fragaria virginiana*	Virginia strawberry	FRVI	**FO**	**H**
27	*Lotus unifoliolatus*	American bird's-foot trefoil	LOUN	**FO**	**H**
28	*Hieracium cynoglossoides*	houndstongue hawkweed	HICY	**FO**	**H**
29	*Symphyotrichum foliaceum*	leafy aster	SYFO2-U	**FO**	**H**
30	*Lupinus argenteus*	silvery lupine	LUAR3	**FO**	**H**
31	*Lupinus sericeus*	silky lupine	LUSE4	**FO**	**H**
32	*Lupinus arbustus*	longspur lupine	LUAR6	**FO**	**H**
33	*Lupinus wyethii*	Wyeth's lupine	LUWY	**FO**	**H**
34	*Eucephalus elegans*	elegant aster	EUEL2	**FO**	**H**
35	*Taraxacum officinale*	common dandelion	TAOF-U	**FO**	**H**
36	*Eriogonum heracleoides*	parsnipflower buckwheat	ERHE2	**FO**	**H**
37	*Achillea millefolium*	common yarrow	ACMI2-U	**FO**	**H**
38	*Allium acuminatum*	tapertip onion	ALAC4	**FO**	**H**
39	*Eriogonum umbellatum*	sulphur-flower buckwheat	ERUM	**FO**	**H**
40	*Phlox hoodii*	spiny phlox	PHHO	**FO**	**H**
41	*Antennaria microphylla*	littleleaf pussytoes	ANMI3	**FO**	**H**

42	*Erigeron compositus*	cutleaf daisy	ERCO4	**FO**	**H**
43	*Erigeron linearis*	desert yellow fleabane	ERLI	**FO**	**H**
44	*Madia gracilis*	grassy tarweed	MAGR3	**FO**	**H**
45	*Chondrilla juncea*	rush skeletonweed	CHJU	**FO**	**H**
46	*Euphorbia esula*	leafy spurge	EUES	**FO**	**H**
47	*Centaurea stoebe* ssp. *micranthos*	spotted knapweed	CESTM	**FO**	**H**
48	*Centaurea diffusa*	diffuse knapweed	CEDI3	**FO**	**H**
49	*Cirsium arvense*	Canada thistle	CIAR4-U	**FO**	**H**
50	*Epilobium brachycarpum*	tall annual willowweed	EPBR3	**FO**	**H**
51	*Sisymbrium altissimum*	tall tumblemustard	SIAL2	**FO**	**H**
52	*Gayphytum diffusum*	spreading groundsmoke	GADI2	**FO**	**H**
53	*Polygonum douglasii*	Douglas' knotweed	PODO4	**FO**	**H**
54	*Medicago sativa*	alfalfa	MESA	**FO**	**H**
	Species not listed above		See Instruction 3 above	**FO**	**H**
	Species unidentifiable		UNKNOWN	**FO**	**H**

Key to Non-Vegetated Land Cover and Land Use Types

		Map Group
1a. Area is currently used for agricultural activity (e.g., a fallow field).	**Agriculture (AGR)**	**N**
1b. Area is not currently used for agricultural activity	2	
2a. Area is currently developed for urban, residential, administrative use	**Developed (DEV)**	**N**
2b. Area is not currently developed for urban, residential, administrative use	3	
3a. Area is dominated by open water or a confined water course	**Water (WA)**	**N**
3b. Area is not dominated by open water or a confined water course	4	
4a. Area is dominated by barren land (e.g., bare ground, bedrock, scree/talus, mines/tailings) or sparse vegetation	**Barren/Rock/Sparse Veg (BR/SV)**	**N**
4b. Area not as above.	**UNDEFINED (UND)**	

References:

Arno, S.F. and R.P. Hammerly. 1984. Timberline: Mountain and Arctic Forest Frontiers. The Mountaineers, Seattle.

Manning, M.E. and W.G. Padgett. 1995. Riparian Community Type Classification for Humboldt and Toiyabe National Forests, Nevada and Eastern California. U.S. Department of Agriculture, Forest Service, Intermountain Region, p. 306.

Appendix A. Absolute and Relative Cover

Absolute cover of a plant species is the proportion of a plot's area included in the perpendicular downward projection of the species. These are the values recorded when sampling a vegetation plot. Relative cover of a species is the proportion it composes of the total plant cover on the plot (or the proportion of a layer's cover). Relative cover values must be calculated from absolute cover values. For example, we estimate overstory canopy cover on a plot as follows: lodgepole pine 42%, Engelmann spruce 21%, and subalpine fir 7%. These values are the absolute cover of each species. The relative cover of each species is calculated by dividing each absolute cover value by their total (70%) as follows:

	Absolute Cover	Calculation	Relative Cover
Lodgepole pine	42%	100 x 42 / 70 =	60%
Engelmann spruce	21%	100 x 21 /70 =	30%
Subalpine fir	7%	100 x 7 /70 =	10%
Total of values	70%		100%

We calculate relative cover of 60% for lodgepole pine. This means that lodgepole pine makes up 60% of the overstory tree canopy cover on the plot. Relative cover always adds up to 100%, but absolute cover does not. Because plant canopies can overlap each other, absolute cover values can add up to more than 100%. In our example, the total of the absolute cover values is 70, but this does not mean that overstory trees cover 70% of the plot. Overstory tree cover would be 70% if there were no overlap between the crowns of the three species, but only 42% with maximum overlap. The actual overstory cover must be determined when sampling the plot if the information is desired, but the sum of the species cover values is used to calculate relative cover.

If the absolute cover values in our example were all halved or all doubled, the relative cover of each species would not change even though overstory tree cover would be very different. Halving the absolute values would mean overstory cover would be between 21 and 35%, depending on the amount of overlap. Doubling the values would mean overstory cover could range from 84 to 100% (not 140%). Each of these scenarios would be very different from the original example in terms of wildlife habitat value, fuel conditions, fire behavior, and silvicultural options, but the relative cover of the tree species would be exactly the same. We should also note that they also could vary widely in spectral signature. The key point here is that relative cover values by themselves provide limited ecological information and may be of little value to resource managers. Relative cover can be derived from absolute cover, but absolute cover cannot be derived from relative cover values. This is why absolute cover is recorded in the field.

Appendix B. Vegetation Group and Vegetation Type Map Unit Codes

Map Group	Code
Alpine	**A**
Riparian	**R**
Herbland	**H**
Shrubland	**S**
Woodland	**W**
Deciduous Forest	**D**
Conifer Forest	**C**
Non-Vegetated / Sparse Vegetation	**N**

Vegetation Type Map Unit	Code
Alpine	**A**
Alpine Vegetation	ALP
Riparian	**R**
Riparian Woody	RW
Riparian Herbaceous	RHE
Herbland	**H**
Grassland	GR
Forbland	FO
Shrubland	**S**
Dwarf Sagebrush	DSB
Mountain Big Sagebrush	MSB
Wyoming Big Sagebrush	WSB
Bitterbrush	BB
Forest Shrubland	FS
Mountain Shrubland	MS
Woodland	**W**
Mountain Mahogany	MM
Pinyon-Juniper	PJ
Juniper Mix	Jmix
Deciduous Forest	**D**
Aspen	AS
Aspen/Conifer	AS/C
Conifer/Aspen	C/AS
Conifer Forest	**C**
Ponderosa Pine	PP
Lodgepole Pine	LP
Douglas-fir	DF
Douglas-fir/Lodgepole Pine	DFL
Engelmann Spruce	ES
Subalpine Fir	SA
Subalpine Fir/Whitebark Pine	SAW
Subalpine Fir/Douglas-fir	SAD
Whitebark Pine Mix	WBmix
Non-Vegetated / Sparse Vegetation	**N**
Agriculture	AGR
Developed	DEV
Barren/Sparse Vegetation	BR/SV
Water	WA

Appendix D: Field Reference Data Collection Guide and Protocols

Sawtooth National Forest
Existing Vegetation Mapping Project
Field Reference Data Collection Guide & Protocols

Introduction

This document will serve as a guide to reference data collection for the Sawtooth National Forest Existing Vegetation Mapping Project. Detailed instructions on how to fill out the datasheets are included in this document. These protocols have been established following the USFS Existing Vegetation Classification and Mapping Technical Guide as well as guidelines from the Remote Sensing Applications Center.

Background

The Sawtooth National Forest is responsible for managing vegetation to meet a variety of uses while sustaining and restoring the integrity, biodiversity, and productivity of ecosystem components and processes. In building the knowledgebase required to accomplish this mission, existing vegetation information is collected through an integrated classification, mapping, and quantitative inventory process. This information structure is essential for conducting landscape analyses and assessments, developing conservation and restoration strategies, and revising land management plans that guide project development and implementation.

The data you collect will be used to create a mid-level (1:100,000 scale) map of current (existing) vegetation communities across the Sawtooth National Forest. Data gathered will include information on species composition, forest and shrub canopy cover, and tree size class. The data will be estimated from a “bird’s eye” or “satellite” view from above. Vegetation canopy overlap will not be considered. Estimations will be done using a combination of ocular estimates and transects.

Tools

You have been provided several tools to assist in the field data collection process. They include:

- Dominance type key
- Field data collection forms
- Field overview maps (1:160,000 scale)

- Field travel maps (1:20,000 scale)
- Plot maps (1:9,000 scale)

General Data Collection Procedures

Field information will be collected from three types of plots:

- Pre-selected field plots
- Field observation polygons
- Opportunistic field plots

Pre-Selected Field Plots

The Sawtooth project area has been divided into 5 geographic areas (Figure 1). Approximately 200-300 pre-selected field plots have been identified for each geographic area (GA). These plots were chosen using spectral information from Landsat Thematic Mapper satellite imagery, elevation, slope, and aspect. They are not a random sample of the mapping area and have not been established along a sample grid or other sampling procedure. Plots were selected in vegetative homogenous areas generally within a quarter mile of a road or along trails. Some plots may be behind closed roads or in roadless areas.

The pre-selected field plots should provide a sample of the landcover communities that occur on the National Forest. For each plot, the composition, canopy cover, and tree size data will be used to determine the vegetation dominance type and the following vegetation map classes (map units): vegetation group, vegetation type, canopy cover, and tree size.

Field Observation Polygons

A minimum of 3, and optionally 4, additional field observation polygons will be collected with each of the pre-selected field plots. You will use the plot maps (1-meter resolution NAIP aerial imagery and segment polygons) to identify observation polygons containing homogenous vegetation and estimate the vegetation group, dominance type, vegetation type, canopy cover class, and tree size class. This provides an opportunity to quickly collect additional vegetation information.

Opportunistic Field Plots

Opportunistic plots can be established for those existing vegetation types that lack adequate representation in the sample. Opportunistic plots are meant to be collected as crews travel to and from the pre-selected plots. Up to a total of 200 opportunistic plots may be established by crews in addition to the pre-selected plots. Opportunistic plots follow the same data collection protocols as the pre-selected plots.

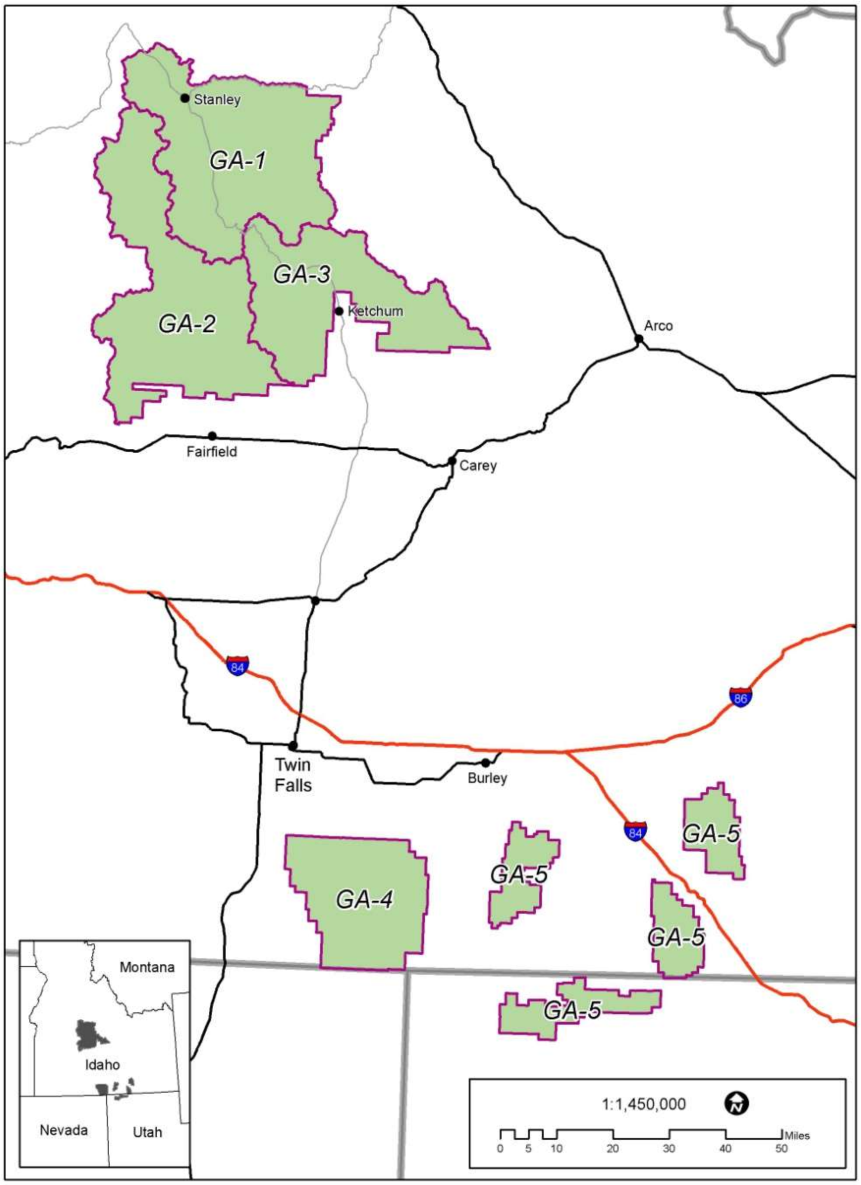


Figure 1. Project Geographic Areas (GA's).

Sampling Process and Data Collection Procedures

The sampling process contains three steps: planning, navigation, and data collection.

Step 1 - Planning

Before leaving the office, each crew should know where they are going, what information is going to be collected, and have the appropriate gear to complete the task. Review the overview maps and travel maps to determine the best travel routes. Check with your supervisor and/or crew lead before leaving. Coordination with designated Forest personnel to ensure access should be completed before leaving for field.

To ensure unique plot numbers are assigned to the collection of opportunistic plots, a set of available plot numbers for each GA should be allocated amongst the crews prior to commencing field work. For example, for GA-1, Crew 1 could be assigned plot numbers 1500 to 1519; Crew 2, 1520-1539, etc. The first digit in the plot number refers to the GA number.

All plots collected must be within the project boundary (i.e. on NF lands designated for the project). They cannot be adjacent to lands of the project boundary. It is the responsibility of the field crew to assure that plots are within the project boundary.

If any plots are revisited, they cannot be labeled as moved or opportunistic and given a second number. It is the responsibility of field crew members to keep track of plots visited and who has been assigned to visit a particular plot.

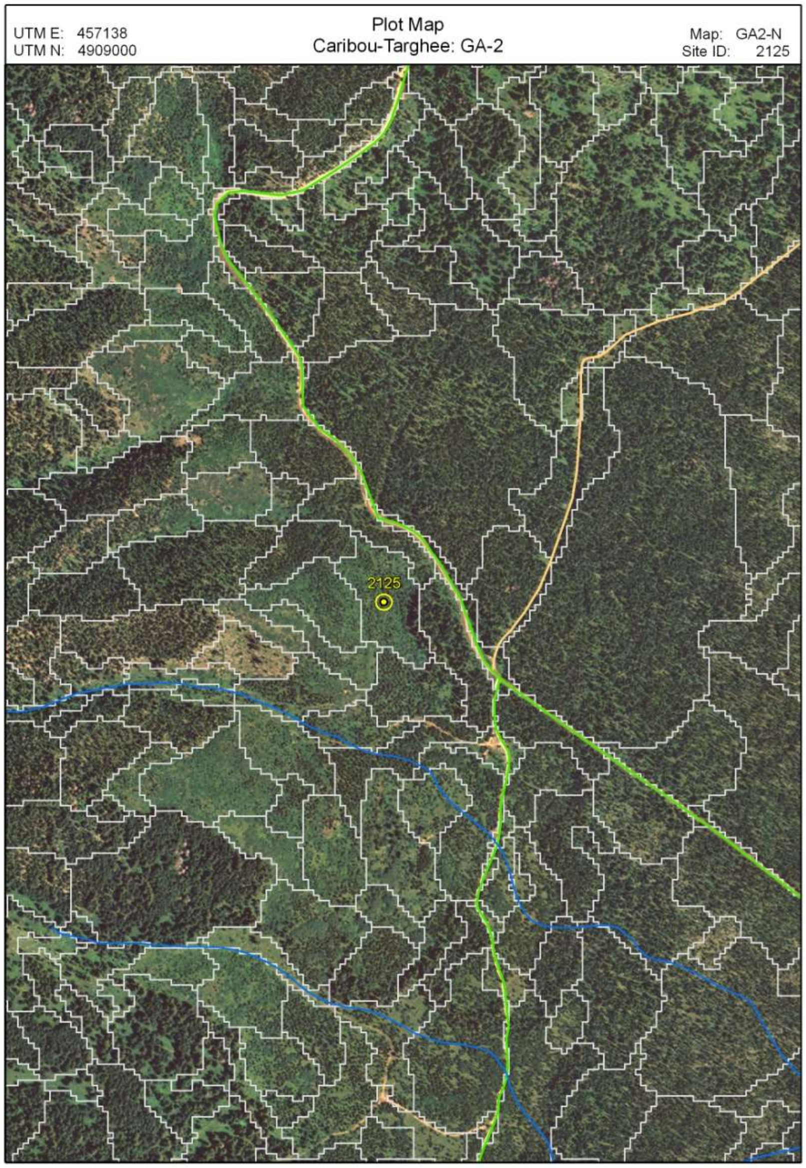
Gear check list:
- GPS unit
- Digital camera
- Batteries (GPS and Camera)
- Data sheets
- Dominance type key
- Travel maps & plot maps
- Pencils & sharpies
- Clinometer
- 100m tape
- 100ft tape
- DBH tape
- Compass
- Flagging
- Pin Flags
- Whiteboard

Step 2 - Navigation

You have been provided with the coordinates of the pre-selected field plot center, and navigation and plot maps with 2009 NAIP aerial imagery in the background to help with navigating to the plot. The waypoints should be pre-loaded on the GPS unit. Plots have been located generally within a ¼ mile of a road or along trails to make them as accessible as possible.

However, there is no guarantee that the plots will be accessible. If you cannot get to the plot, but can clearly see it from some vantage point, fill out as much information as possible and note the plot as viewed from a distance. If a plot is completely inaccessible and cannot be viewed, note that the plot is not observable, and either go on to the next plot location or move the plot to a nearby area comprised of similar vegetation and topographic characteristics as identified on the plot map including vegetation type, aspect, and slope. If a plot is relocated, note the plot as a moved on the field form. Do not assign a new plot number to a moved plot or record it as an opportunistic plot.

As you navigate between pre-selected field plots, look for vegetation types that have not been adequately sampled. A list of underrepresented types will be provided by the Forest Service at regular intervals throughout the field season. Collect an opportunistic field plot using a new field form, assign a new plot number, and note the plot as an opportunistic plot.



Plot map showing pre-selected field plot locations, roads (color-coded by type), streams, and segment polygons.

<u>Step 3- Data Collection</u>

- Pre-selected field plots

Once you arrive at the field plot, make sure it is representative of the segment polygon as identified on the plot map. Walk through the segment area 100-200 feet around the plot center. If the pre-selected plot is not representative of the segment polygon, move the plot center to a more representative location within the segment. This option should be used with caution and good judgment. If the segment is very heterogeneous, sample the most representative vegetation community type (i.e. of which type the segment is mostly comprised). In the Notes section of the field form, include rationale for moving the plot, and details of dominance composition with the segment.

The size of each plot is a 50 foot radius circle. Once the location of the plot has been determined, place flagging or a pin flag at the plot center. Pace or measure and flag the plot boundaries in each cardinal direction from the center of the plot. In designated Wilderness Areas, use sticks or rock cairns to mark the plot instead of flagging. Estimate all vegetation data within the plot area from a "bird's eye" view or top-down perspective. It is important to walk through the entire plot before estimating species, canopy cover, and tree size class. It may also be helpful to mark out a 5 foot radius subplot representing 1 percent of the plot area to assist in calibrating your estimates.

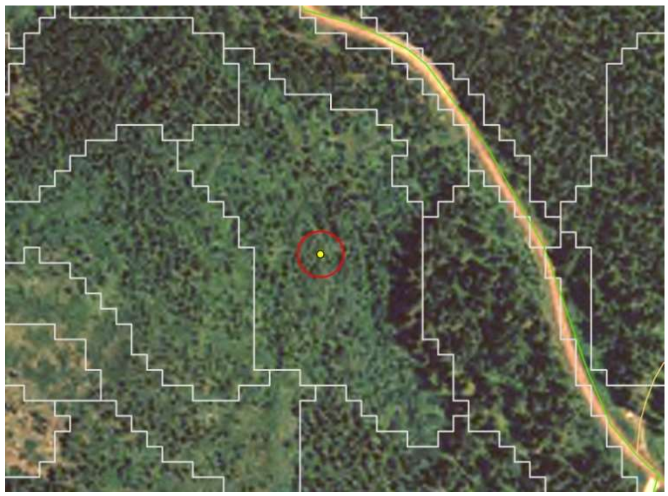


Image map showing plot center location and corresponding 50 foot radius plot boundary within a segment polygon representing relatively homogeneous vegetation.

For the first 5 shrubland plots per observer, use the transect intercept method to determine the shrub canopy cover to calibrate subsequent ocular estimates. For every 3-5 shrubland plots thereafter (per observer), use the transect intercept method to maintain consistency of your ocular estimates. The intercept method involves laying out four 50-foot transects in each cardinal direction from the plot center using tapes and stakes. Do not allow the vegetation to deflect the alignment of the tape. Estimate and record the number of feet of live canopy cover intercepted for each species within each 10-foot transect increment. Round the estimate to the nearest 0.5 foot for each 10-foot increment. Gaps within a single plant, flowers, and flower stalks should be counted as part of the shrub. The combined percentages from the north-south transects and east-west transects are then averaged to calculate the overall shrub canopy cover.

- Field Observation Polygons

For each of the pre-selected field plots, 3 to 4 field observation polygons will be collected using the plot map (1:9000 scale with NAIP imagery as a backdrop). On the plot map, identify a segment polygon representing an area of homogenous vegetation, label it A, B, C, or D, and fill in the appropriate information on the left side of the back of the field plot form. Here you will provide general information on the vegetation group, dominance type, vegetation type, canopy cover class, and tree size class. Where easily identifiable, target a variety of vegetation types and structure classes to capture the representative vegetation communities occurring in the project area.

If you cannot correctly make a determination on all of these calls, complete those that you have confidence in. Make sure the labels are legible and the segment polygons you select represent areas of homogenous vegetation composition, including canopy cover and tree size class. If you cannot adequately identify the segment on the plot map (i.e. heavily forested areas) then record the GPS location so that the precise location can be accurately located and used for the vegetation modeling aspects of the project.

Of particular interest are segment polygons containing homogenous vegetation types that have not been adequately sampled. The crew lead will provide an updated list of these types throughout the field season. Again, any vegetation type collected should be homogenous and should not consist of an inclusion representing only a small proportion or rare occurrence on the landscape.

- Opportunistic Plots

While you are traveling from plot to plot and you identify areas containing vegetation types that have not been adequately sampled, you can establish opportunistic field plot locations and collect vegetation information in the same way as specified for the pre-selected plots. Four principles should guide your selection of opportunistic field plots:

Plots will represent vegetation types that are underrepresented, as directed by project personnel.
Plots should be located in vegetation types that are homogenous across segment polygons (at least 5 acres in size or 2 acres for riparian and aspen communities).
The plot should represent a single vegetation life form and not consist of an inclusion.
The plot should not cross roads, major topographic breaks, major streams, etc.

Opportunistic plots **must** be given a completely new number; a previously assigned number cannot be used for an opportunistic plot. Field crews will allocate a set of numbers so that no one will duplicate a number. The individual crew will be responsible for keeping track of their numbers previously used for opportunistic plots.

Initial direction regarding what is considered underrepresented will be given at the start of the project. As field data sheets are received by project personnel, tracking and tallying of both the map units being collected and their distribution will assist with future selection of opportunistic plots. It is the responsibility of field crews to coordinate with Forest Service personnel in the appropriate collection of opportunistic plots, which can be modified as the field data collection progresses.

Data Collection Forms

This section provides information on how to fill out the datasheets.

Field Plot Form

1. Plot ID — Record the 4-digit field plot number.

2. Names of collectors— Record the names of the personnel collecting the data. Initials can be used if they are unique to the entire team. However, names are preferred on the first few forms for each geographic area.

3. Month/Day/Year

4. Level of Observation— Record the level of observation. “VI” stands for visited field plot, “VFD” stands for plot viewed from a distance, “NO” stands for not observable, “MV” stands for moved plots, and “OPP” stands for opportunistic plot.

5. UTM E & N— Record the coordinates for the center of the plot. You should collect a minimum of 30-60 positions for non-forested plots and 60-90 positions for forested plots (or as many as possible if experiencing difficulty). It is important to collect positions **from the plot center**, so be at the center to start collection. Every plot should use a PDOP mask of 6 and elevation mask of 15. If the GPS is not working (low satellites, etc.), then raise the PDOP, using the highest accuracy (i.e. the lowest number) possible. In the Notes section, record changes to PDOP and elevation masks. If using a GPS unit where the PDOP and elevation masks cannot be set, verify a precision of ≤30 feet before collecting positions.

GPS unit should be set to the following projection:

UTM, Zone 11
NAD83
GRS1980

6. Field Photograph— Take a single representative photo of the field site (more can be taken if necessary) and record the digital photo number. Take the photo from a location along the plot perimeter that has a side-hill view toward the plot center to capture the slope of the site. This photo number will need to be completely unique to all photos taken so that when it is transferred it does not get confused with other photos. The photos should be renamed at a later time to match the field plot number and cardinal direction taken (e.g. 1224W). A whiteboard or other marker with the field site number can also be used when taking the photo to help identify the site.

7. Geographic Area— Record the geographic area (GA) that the site is located in. This number should appear on the field plot list and plot map.

8. Ocular Plot Composition— (Estimated from a "Top-down" perspective). Estimate and record the total canopy cover for trees, shrubs, herbaceous, and non-vegetated. Woodland species are included with trees for the ocular plot composition by lifeform. Determine percent canopy cover as if you were looking down on the stand from the air; do not double count overlapping layers that are not viewable from above. For example, smaller sized trees being overlapped by larger ones will be ignored and not counted in the canopy cover estimate. The sum of all life form and non-vegetation type totals must add up to 100%.

List up to the 5 most abundant species and non-vegetation types having ≥5% cover using the PLANTS codes from the Sawtooth species list and non-vegetation type codes from Table 1. Start by listing tree species, then shrubs, herbaceous, and non-vegetated. If the code for any species is not known, its name should be written out and the code looked up later. If a plant can only be identified to the genus level, e.g. due to seasonal condition or disturbance, record only the plant genus and make a note of it on the form. There is one exception where species occurring with less than 5% cover would be recorded. Where the most abundant tree, shrub, and herbaceous species occur with <5% cover, record the most abundant species for each lifeform in order to determine dominance type and corresponding vegetation type map unit.

Table 1. Non-vegetation Type Codes

BARE	Bare soil - soil particles <2mm in diameter
ROCK	Rock >2mm in diameter
LITT	Plant litter and duff, including twigs <1/4 inch in diameter
WOOD	Dead wood material >1/4 inch in diameter, including bases of standing dead trees and shrubs
SNOW	Area covered by permanent ice and/or snow
WATE	Water that obscures other cover types

For each of the listed species/non-vegetation types, estimate and record the percent canopy cover as viewed from above. Record the combined percent cover of all "other" species/non-vegetation types that were not individually listed on the form in the previous step. Cover estimates for each life form/non-vegetation component must sum to the total cover estimates previously recorded.

This will allow for making a determination of the vegetation and ground cover types that are occupying the plot without collecting a complete species list.

9. Tree Size Class— (Estimated from a "Top-down" perspective). For forest and woodland sites only (≥10% tree), list out each tree species and cover as recorded in #8. For each species, determine the percent cover of each overstory tree size class and enter it in the size class columns. Determine percent cover of each size class as if you were looking down on the stand from the air; do not double count overlapping layers that are not viewable from above. For example, smaller sized trees that are being overlapped by larger ones will be ignored and not counted in the size class estimate. Total the estimated percent cover for each size class.

Tree size will be determined by estimating diameter at breast height (DBH) for all tree species except those designated woodland species in Table 2. For designated woodland species, tree size will be determined by estimating diameter at root collar (DRC). Instructions for determining DRC for woodland species are found in Appendix A.

Table 2. Sawtooth DRC Measured Woodland Species

JUOS	Juniperus osteosperma	Utah juniper
JUSC2	Juniperus scopulorum	Rocky Mountain juniper
PIMO	Pinus monophylla	singleleaf pinyon
ACGR3	Acer grandidentatum	bigtooth maple
CELE3	Cercocarpus ledifolius	curlleaf mountain mahogany

For the first 5 tree sites, measure DBH or DRC to calibrate subsequent ocular estimates. For every 3-5 plots thereafter (per observer), measure DBH or DRC to maintain consistency of your ocular estimates.

10. Shrub Canopy Cover by line intercept— (Only use if Lifeform is likely to be Shrubland – not for tree sites). List the Plant Codes for each major shrub species.
Lay out four 50-foot transects in each cardinal direction from the plot center. Estimate and record the number of feet of live canopy cover intercepted for each species within each 10-foot transect increment. Gaps within a single plant, flowers, and flower stalks should be counted as part of the shrub. Total the % cover for each species on the right. Then total all shrub species percents for the combined north-south and east-west transects. Calculate the overall shrub canopy cover by averaging the total shrub cover from the combined north-south and east-west transects. A measured line intersect should be completed for every 3 to 5 shrubland sites visited to help maintain consistency for the ocular plot composition estimate (#8).

Plot Summary

11. Vegetation Group— Based on the canopy cover from the ocular plot composition (#8) and classification key, determine the vegetation group and record it as the first call ("1st" column). A list of the vegetation groups can be found in Appendix B. If shrub canopy information from transects (#10) has been collected, use the overall shrub transect cover to determine the vegetation group. If the ocular estimate is considered to be more representative of the plot, use the ocular estimate to determine the vegetation group. Include a comment in the notes indicating the ocular estimate was used to make the vegetation group call.

If a plot is near the borderline between vegetation groups, record the secondary group in the "2^{nd}" column. For example, if tree canopy cover totals 12 percent, record Conifer or Deciduous Forest or Woodland as the first call, and Shrubland, Herbaceous, or Non-vegetation as the second call based on the cover of those groups. As another example, if shrub canopy cover totals 12 percent on a plot that is clearly not forest or woodland, record Shrubland as the first call and Herbaceous or Non-vegetation as the second call based on the cover of those groups.

12. *Dominance Type*— Based on the ocular plot composition (#8) and the dominance classification key, determine the dominance type and record it in the "1st" column. The full dominance type list can be found in the dominance key. For shrubland plots, if shrub canopy information from transects (#10) has been collected, use the shrub species transect cover to determine the dominance type. If the ocular estimate is considered to be more representative of the plot, use the ocular estimate to determine the dominance type. Include a comment in the notes indicating the ocular estimate was used to make the dominance type call. If a plot is near the borderline between dominance types, record the secondary dominance type in the "2nd" column.

13. *Vegetation Type*— Based on the dominance type classification, determine the vegetation type and record it in the "1st" column. If a plot is near the borderline between vegetation types, record the secondary type in the "2nd" column based on the secondary dominance type. A list of the vegetation types can be found in Appendix B.

14. *Canopy Cover*— Based on the predominant vegetation group, determine the canopy cover class for forest, woodland, and shrubland sites and record it in the "1st" column. Upland and riparian forest/woodland should be assigned a forest canopy cover class. Upland, riparian, and alpine shrubland should be assigned a shrubland canopy cover class. A list of the canopy cover classes can be found in Appendix B. For shrubland plots, if shrub canopy information from transects (#10) has been collected, use the overall shrub transect cover to determine the canopy cover class. If the ocular estimate is considered to be more representative of the plot, use the ocular estimate to determine the canopy cover class. Include a comment in the notes indicating the ocular estimate was used to make the canopy cover class call.

If a plot is near the borderline between canopy classes, record the secondary class in the “2nd” column. The secondary canopy class should be based on the secondary vegetation group if it is different from the primary vegetation group.

15. *Tree Size Class*— Based on the tree size class (#9) determine the most abundant size class and record it in the “1st” column. In case of a tie, record the highest tree size class. A list of the tree size classes can be found in Appendix B. If a plot is near the borderline between classes, record the secondary class in the “2nd” column.

16. *Disturbance Event*— If there is evidence of a relatively recent disturbance event (fire, timber harvest, insect outbreak, wind event, etc.) within the last 5 years, check the appropriate box and include any relevant information such as whether the site was previously forested, contains standing dead trees, etc. in the notes section.

17: *Notes*— Record a description of the plot. Include information on the vegetation conditions, disturbances, approximate age of the disturbance, and any other information that is not included in the field form. This description is often the most valuable piece of information we have about a plot and provides details that can have an effect on the mapping process.

<u>*Observation Polygon Form*</u>
Three or four additional field observation polygons will be collected for each of the given field plots. Using the image plot maps provided (NAIP imagery, 1-meter resolution), identify a segment polygon representing an area of homogenous vegetation, label it (A, B, C, or D), and fill in the data on the left side of the field form. This data provides general information on the vegetation group, dominance type, vegetation type, canopy closure, and tree size class. Make sure the labels are legible and the segments represent groups of homogenous vegetation, including canopy cover and size class. Only record data you have a high level of confidence in, for example you may need to walk through a polygon in order to determine the dominance type or tree size class. The canopy cover information on the right side of the field form (8-12) will be collected at a later time using photo-interpretation techniques. If you think it would be helpful, designate a symbol on the NAIP plot map to indicate where you were standing when you made the field observation.

1. <u>Vegetation Group</u>— Ocular estimate of dominant vegetation group for the segment polygon you identified on the plot map

2. <u>Dominance Type</u>— Ocular estimate of the dominance type for the segment polygon you identified on the plot map

3. Vegetation Type— Ocular estimate of the vegetation type for the segment polygon you identified on the plot map

4. Canopy Cover— Ocular estimate of the canopy cover class using 5% increments for the segment polygon you identified on the plot map

5. Tree Size Class— Ocular estimate of the tree size class for the segment polygon you identified on the plot map

6. Coordinates— If the segment polygon was difficult to identify on the plot map, and you had to walk into the site to determine the vegetation characteristics, take the center coordinates.

7. Notes— Record any information, such as site description or general vegetation conditions, that may be relevant to the site.

Appendix A.

Diameter at Root Collar (DRC)
(Adapted from Interior West Forest Inventory and Analysis P2 Field Procedures, V5.00)

For species requiring diameter at the root collar, measure the diameter at the ground line or at the stem root collar, whichever is higher. For these trees, treat clumps of stems having a unified crown and common root stock as a single tree; examples include mesquite, juniper, and mountain mahogany. Treat stems of woodland species such as Gambel oak and bigtooth maple as individual trees if they originate below the ground.

Measuring woodland stem diameters: Before measuring DRC, remove the loose material on the ground (e.g., litter) but not mineral soil. Measure just above any swells present, and in a location so that the diameter measurements are a good representation of the volume in the stems (especially when trees are extremely deformed at the base). Stems must be at least 1 foot in length and at least 1.0 inch in diameter 1 foot up from the stem diameter measurement point to qualify for measurement. Whenever DRC is impossible or extremely difficult to measure with a diameter tape (e.g., due to thorns, extreme number of limbs), stems may be estimated and recorded to the nearest class. Additional instructions for DRC measurements are illustrated in Figures A and B.

Computing and Recording DRC: For all trees requiring DRC, with at least one stem 1 foot in length and at least 1.0 inch in diameter 1 foot up from the stem diameter measurement point, DRC is computed as the square root of the sum of the squared stem diameters. For a single-stemmed DRC tree, the computed DRC is equal to the single diameter measured.

Use the following formula to compute DRC:

$DRC = SQRT\ [SUM\ (stem\ diameter^2)]$
Round the result to the nearest 0.1 inch. For example, a multi-stemmed woodland tree with stems of 12.2, 13.2, 3.8, and 22.1 would be calculated as:

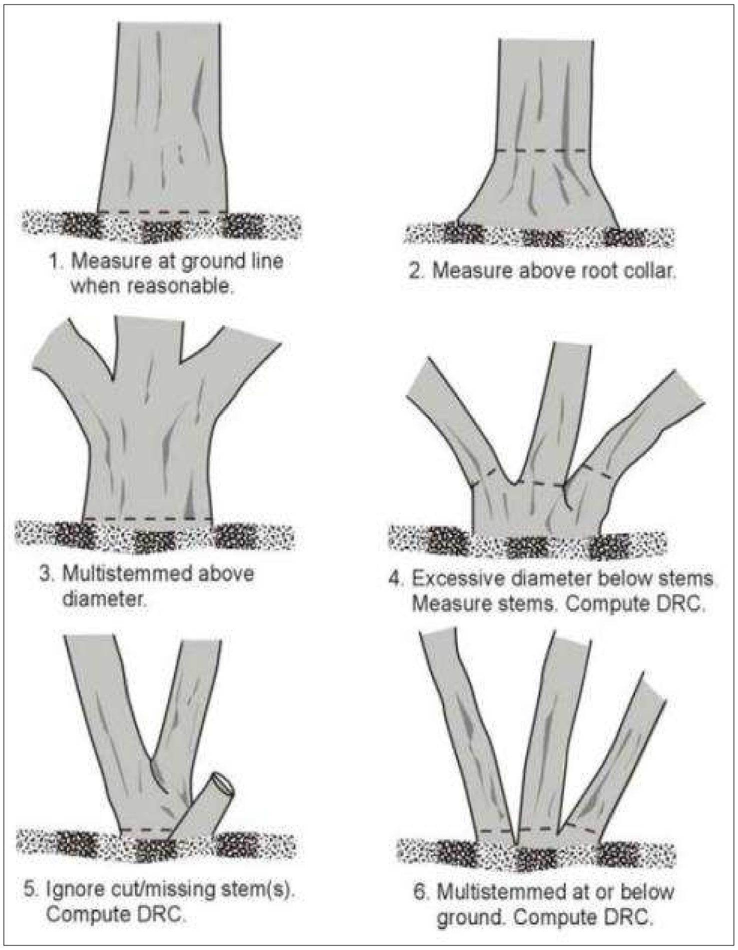
$DRC = SQRT\ (12.2^2 + 13.2^2 + 3.8^2 + 22.1^2)$

$= SQRT\ (825.93)$

$= 28.74$

$= 28.7$

If a previously tallied woodland tree was completely burned and has re-sprouted at the base, treat the previously tallied tree as dead and the new sprouts (1.0-inch DRC and larger) as part of a new tree.



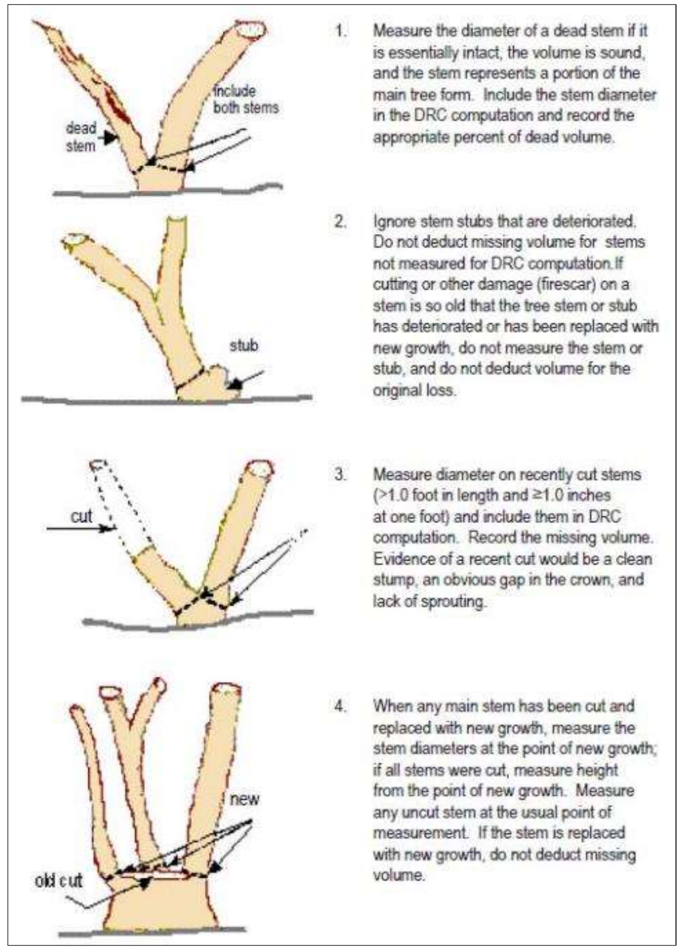


Figure A. How to measure DRC in a variety of situations. The cut stem in example number 5 is < 1 foot in length.

Figure B. Additional examples of how to measure DRC.

Appendix B. Vegetation Group, Vegetation Type, Canopy Cover Class, and Tree Size Class Codes

Vegetation Group	Code
Conifer Forest	**C**
Deciduous Forest	**D**
Shrubland	**S**
Herbland	**H**
Riparian	**R**
Alpine	**A**
Sparse Vegetation	**V**
Burned Area	**B**
Non-Vegetated	**N**
Woodland	**W**

Vegetation Type	Code
Alpine	
Alpine	**ALP**
Riparian	
Riparian Deciduous Forests & Woodlands	**RDE**
Riparian Shrublands	**RSH**
Shrubby Cinquefoil – Silver sagebrush	**RSS**
Riparian Herblands	**RHE**
Riparian Wetlands	**WET**
Herbland	
Perennial Grasslands	**PG**
Annual Grasslands	**AG**
Disturbed Forest Forblands	**DFO**
Upland Forblands	**UFO**
Shrubland	
Low Sagebrush	**LS**
Mountain Big Sagebrush	**MB**
Wyoming Big Sagebrush	**WY**
Bitterbrush Shrublands	**BB**
Forest Shrublands	**FS**
Mountain Shrublands	**MS**
Forest	
Aspen	**AS**
Aspen-Conifer	**ASC**
Conifer-Aspen	**CAS**
Whitebark Pine	**WB**

Vegetation Type	Code
Limber Pine	**LM**
Ponderosa Pine	**PP**
Lodgepole Pine	**LP**
Douglas-fir	**DF**
Douglas-fir – Ponderosa Pine	**DFP**
Douglas-fir – Lodgepole Pine	**DFL**
Engelmann Spruce	**ES**
Subalpine Fir	**SA**
Subalpine Fir – Whitebark Pine	**SAW**
Subalpine Fir – Limber Pine	**SAL**
Subalpine Fir – Douglas-fir	**SAD**
Woodland	
Mountain Mahogany	**MM**
Singleleaf Pinyon	**SP**
Pinyon-Juniper	**PJ**
Utah Juniper	**UJ**
Bigtooth Maple	**BTM**
Sparse Vegetation	
Sparse Vegetation	**SV**
Non-Vegetated	
Burned – Standing Dead Trees	**SBT**
Agriculture	**AGR**
Developed	**DEV**
Barren/Rock	**BR**
Water	**WA**

Tree Canopy Cover Class	Code
10 - 29%	TC1
30 - 39%	TC2
40 - 59%	TC3
≥ 60%	TC4

Shrub Canopy Cover Class	Code
10 - 14%	SC1
15 - 24%	SC2
25 - 34%	SC3
≥ 35%	SC4

Tree Size Class	Code
< 4.5 feet tall	TS1
0.0-4.9”	TS2
5.0-7.9”	TS3
8.0-9.9”	TS4
10.0-11.9”	TS5
12.0-15.9”	TS6
16.0-19.9”	TS7
20.0-29.9”	TS8
≥ 30”	TS9

Region 4 - Sawtooth NF - FIELD PLOT FORM v6/16/2011

1- PlotID# ___________ 2- Names: ____________________________ 3- M/D/YY ___-___-___

4- Level of Observation: VI VFD NO MV OPP

5- UTM E: ____________________ N: ______________________ (UTM, NAD83, GRS1980, Zone 11)

6- Field Photograph: ______________________ 7- Geographic Area: 1 2 3 4 5

8- "OCULAR" Plot Composition

Tree	Cover	Shrub	Cover	Herbaceous	Cover	Non-veg	Cover
Other		Other		Other		Other	
Total		Total		Total		Total	
						Lifeform & Non-Veg totals must add up to 100%	

9- Tree DBH or DRC Size Class

Plant Code	Cover	TS1	TS2	TS3	TS4	TS5	TS6	TS7	TS8	TS9
Other										
Total										

Tree Size Classes	
TS1	< 4.5 feet tall
TS2	0.0-4.9"
TS3	5.0-7.9"
TS4	8.0-9.9"
TS5	10.0-11.9"
TS6	12.0-15.9"
TS7	16.0-19.9"
TS8	20.0-29.9"
TS9	≥ 30"

10- Shrub Canopy Cover - by line intercept

North Transect / South Transect

Plant Code	0-10'	10-20'	20-30'	30-40'	40-50'	0-10'	10-20'	20-30'	30-40'	40-50'	Total
Other											
								Total N/S Shrub CC			

East Transect / West Transect

Plant Code	0-10'	10-20'	20-30'	30-40'	40-50'	0-10'	10-20'	20-30'	30-40'	40-50'	Total
Other											
								Total E/W Shrub CC			
								Overall Shrub CC			

PLOT SUMMARY

	1st	2nd
11- Veg Group		
12- Dom Type		
13- Veg Type		
14- Crpy Cover		
15- Tree Size		

16- Disturbance Event: ☐ Burn ☐ Harvest ☐ Other

17- Notes:

17- Notes (cont.):

OBSERVATION POLYGON FORM

Field Observation — PI Canopy Cover

Polygon |A|
1-Veg Group |________________| 7-Notes:
2-Dom Type |________________|
3-Veg Type |________________|
4-Crpy Cover |________________|
5-Tree Size |________________|
6-Coordinates:

8-Conifer Canopy Cover |______|
9-Deciduous Canopy Cover |______|
10-Shrub Canopy Cover |______|
11-Herbaceous Cover |______|
12-Non-Vegetated Cover |______|
TOTAL COVER: | 100% |

Polygon |B|
1-Veg Group |________________| 7-Notes:
2-Dom Type |________________|
3-Veg Type |________________|
4-Crpy Cover |________________|
5-Tree Size |________________|
6-Coordinates:

8-Conifer Canopy Cover |______|
9-Deciduous Canopy Cover |______|
10-Shrub Canopy Cover |______|
11-Herbaceous Cover |______|
12-Non-Vegetated Cover |______|
TOTAL COVER: | 100% |

Polygon |C|
1-Veg Group |________________| 7-Notes:
2-Dom Type |________________|
3-Veg Type |________________|
4-Crpy Cover |________________|
5-Tree Size |________________|
6-Coordinates:

8-Conifer Canopy Cover |______|
9-Deciduous Canopy Cover |______|
10-Shrub Canopy Cover |______|
11-Herbaceous Cover |______|
12-Non-Vegetated Cover |______|
TOTAL COVER: | 100% |

Polygon |D|
1-Veg Group |________________| 7-Notes:
2-Dom Type |________________|
3-Veg Type |________________|
4-Crpy Cover |________________|
5-Tree Size |________________|
6-Coordinates:

8-Conifer Canopy Cover |______|
9-Deciduous Canopy Cover |______|
10-Shrub Canopy Cover |______|
11-Herbaceous Cover |______|
12-Non-Vegetated Cover |______|
TOTAL COVER: | 100% |

Tree Cover Classes:

TC1	10 - 29%
TC2	30 - 39%
TC3	40 - 59%
TC4	≥ 60%

Shrub Cover Classes:

SC1	10 - 14%
SC2	15 - 24%
SC3	25 - 34%
SC4	≥ 35%

Appendix E: eCognition Layer Weights

Layer weights used to develop the modeling units (segments) in eCognition software

Layer	Weight
Landsat TM5 – August 2010 (1^{st} Principal Component)	1.0
Resource photography 2010 (0.5-meter) – Band 1	1.0
Resource photography 2010 (0.5-meter) – Band 2	1.0
Resource photography 2010 (0.5-meter) – Band 3	1.0
Resource photography 2010 (0.5-meter) – Band 4	2.0
Resource photography 2010 (0.5-meter) - NDVI	1.0
Trishade – Band 1	0.3
Trishade – Band 2	0.3
Trishade – Band 3	0.3
Valleybottom	1.0

Appendix F: Tree Size Class Modeling Data Layers

Additional data layers used in the modeling of tree size

Data Source	# of Layers	Spatial Resolution	Description	Statistics Used	Total # of Predictors
VCT	1	30m	Vegetation change tracker algorithm to Identify where change has and has not occurred from 1986 to 2011	Maximum, Mean and Standard Deviation	3
VCT	1	30m	Vegetation change tracker algorithm to Identify when change has occurred from 1986 to 2011	Mean and Standard Deviation	2
VCT	1	30m	Vegetation change tracker algorithm to Identify the magnitude of change that occurred from 1986 to 2011	Majority	1
Vegetation Type Map	1	10m	The mid-level existing vegetation map	Majority	1

Appendix G: Draft Map Review

SAWTOOTH NATIONAL FOREST

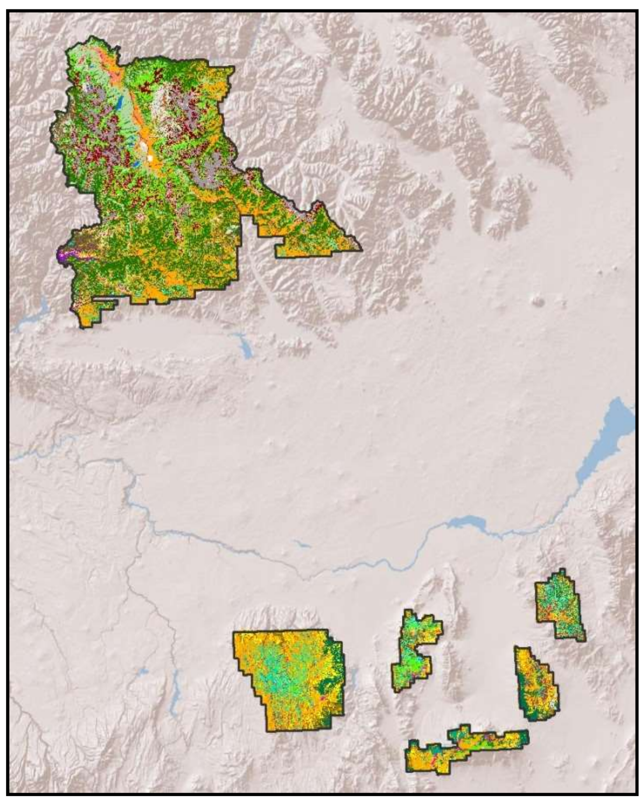
EXISTING VEGETATION MAPPING - DRAFT MAP REVIEW

January 22, 2014

Background:

The Remote Sensing Applications Center (RSAC) was tasked by the Sawtooth National Forest and Intermountain Region to develop a set of mid-level existing vegetation maps. Existing vegetation is the plant cover, or floristic composition and vegetation structure, occurring at a given location at the current time (Brohman and Bryant 2005). This should not be confused with Potential Natural Vegetation (PNV) which describes the vegetation communities that would be established if all successional sequences were completed without interference by man under the present climatic and edaphic conditions (Tuxen 1956). The final map products for this project will include existing vegetation type, canopy cover, and tree size class.

The project has utilized remote sensing techniques and field data to map existing vegetation types. During this process, RSAC has worked with the Forests and the Regional Office to collect and develop the data layers required for implementing semi-automated remote sensing techniques. High resolution aerial imagery collected in 2009 was used to create "mapping segments" (GIS polygons) from a combination of spectral information and physical characteristics of the landscape. These segments were then assigned a vegetation type using an ensemble classifier. The vegetation types on the draft maps have been aggregated to a 1 acre map feature (polygon) size. However, map feature sizes for the final map will consist of 2 acres for riparian types and 5 acres for upland types. The final maps will be produced at a 1:100,000 scale.



This review will focus on the draft vegetation type map only. The meeting scheduled at the Supervisor's Office in Twin Falls is planned to solicit feedback from knowledgeable staff members who can evaluate the draft maps and help improve the depiction of existing vegetation on the final maps. Map revisions will be based almost entirely on the information provided from the review process. Digital maps are available via Webmap. Hardcopy maps have also been produced for each ranger district at scales ranging from 50,000 to 170,000.

Vegetation type map units:

Not all vegetation types have been mapped in each district. The reference sites were reviewed at the beginning of the modeling process and the vegetation types to be depicted on the draft map were finalized. A list of the vegetation type map units and acres forest-wide and of each type in each district are on the following pages.

Vegetation Type	Acres	Percentage
Aspen	74,849	3.4%
Aspen/Conifer Mix	34,848	1.6%
Conifer/Aspen Mix	17,674	0.8%
Douglas-fir	415,821	19.0%
Douglas-fir/Lodgepole Pine Mix	16,837	0.8%
Engelmann Spruce	13,944	0.6%
Lodgepole Pine	120,402	5.5%
Ponderosa Pine	6,384	0.3%
Subalpine Fir	133,153	6.1%
Subalpine/Douglas-fir Mix	38,857	1.8%
Subalpine/Whitebark Pine Mix	84,883	3.9%
Whitebark Pine	60,422	2.8%
Mountain Mahogany	10,232	0.5%
Pinyon-Juniper Mix	13,558	0.6%
Utah Juniper	49,934	2.3%
Bitter Brush	12,061	0.6%
Dwarf Sagebrush	68,745	3.1%
Mountain Big Sagebrush	521,015	23.8%
Wyoming Big Sagebrush	24,511	1.1%

Forest Shrubland	51,426	2.3%
Mountain Shrubland	96,140	4.4%
Alpine Herbaceous	22,642	1.0%
Forbland	25,562	1.2%
Grassland	83,664	3.8%
Riparian Forest/Shrub	20,253	0.9%
Riparian Herbaceous	11,084	0.5%
Agriculture	1,692	0.1%
Barren/Sparse Vegetation	148,918	6.8%
Developed	4,085	0.2%
Water	8,768	0.4%
Total	**2,192,365**	**100.0%**

	Sawtooth NRA		Fairfield		Ketchum		Minidoka	
Vegetation Type	**Acres**	**Percentage**	**Acres**	**Percentage**	**Acres**	**Percentage**	**Acres**	**Percentage**
Aspen	3,106	0.38%	9,390	2.26%	6,034	1.83%	56,319	8.88%
Aspen/Conifer Mix	384	0.05%	2,932	0.70%	1,730	0.52%	29,803	4.70%
Conifer/Aspen Mix	340	0.04%	6,595	1.59%	3,245	0.98%	7,494	1.18%
Douglas-fir	129,460	15.93%	150,204	36.11%	109,840	33.30%	26,317	4.15%
Douglas-fir/Lodgepole Pine Mix	15,909	1.96%	600	0.14%	328	0.10%	0	
Engelmann Spruce	10,520	1.29%	2,270	0.55%	1,154	0.35%	0	
Lodgepole Pine	104,056	12.81%	6,201	1.49%	5,394	1.64%	4,751	0.75%
Ponderosa Pine	6	0.00%	6,378	1.53%			0	
Subalpine Fir	88,201	10.86%	15,882	3.82%	10,229	3.10%	18,841	2.97%
Subalpine/Douglas-fir Mix	17,464	2.15%	8,684	2.09%	12,709	3.85%	0	
Subalpine/Whitebark Pine Mix	65,139	8.02%	12,503	3.01%	7,241	2.20%	0	
Whitebark Pine	50,175	6.18%	3,364	0.81%	6,883	2.09%	0	
Mountain Mahogany							10,232	1.61%
Pinyon-Juniper Mix							13,558	2.14%
Utah Juniper							49,934	7.88%
Bitter Brush	20	0.00%	5,062	1.22%	10	0.00%	6,969	1.10%
Dwarf Sagebrush	477	0.06%	25	0.01%			68,243	10.76%
Mountain Big Sagebrush	95,175	11.71%	113,473	27.28%	105,472	31.97%	206,896	32.63%
Wyoming Big Sagebrush							24,511	3.87%
Forest Shrubland	15,673	1.93%	15,472	3.72%	11,449	3.47%	8,832	1.39%
Mountain Shrubland	7,858	0.97%	20,250	4.87%	8,670	2.63%	59,362	9.36%
Alpine Herbaceous	11,445	1.41%	4,566	1.10%	6,630	2.01%	0	
Forbland	15,258	1.88%	6,464	1.55%	3,840	1.16%	0	
Grassland	32,108	3.95%	10,228	2.46%	5,188	1.57%	36,141	5.70%
Riparian Forest/Shrub	10,223	1.26%	3,654	0.88%	3,573	1.08%	2,802	0.44%
Riparian Herbaceous	10,281	1.27%	512	0.12%	291	0.09%	0	
Agriculture	1,547	0.19%					145	
Barren/Sparse Vegetation	118,485	14.58%	10,600	2.55%	17,847	5.41%	1,986	0.31%
Developed	1,300	0.16%	67	0.02%	2,001	0.61%	717	0.11%
Water	7,920	0.97%	568	0.14%	121	0.04%	158	0.02%
Total	**812,530**	**100%**	**415,946**	**100%**	**329,878**	**100%**	**634,011**	**100%**

Review Process:

For the review, provide as much information about the draft map as possible. You have been provided with digital and hardcopy draft maps. Either form of review is acceptable… Overall, it is important to focus your attention on the general vegetation patterns and distribution of vegetation types. We need information on what is correct and what is incorrect. Please remember this is a mid-level map (1:100,000 scale) and not a site map. The minimum size of an area that will be depicted on the final map is 5 acres for upland types and 2 acres for riparian types. This is not project level mapping; fine scaled vegetation patches or stands will not be represented on the final map.

For either the hard copy or digital map review you must follow the "Sawtooth Vegetation Keys" when determining the vegetation type map unit. This ensures that everyone is assigning types based on the same rules and descriptions.

In general, the draft map review process includes the following phases:

Review the forest and district proportion summaries provided in this procedure.

Review the entire district you work on. Focus on general vegetation distribution and patterns and determine if the overall community types that you see are represented.

Next focus on specific areas that you are most familiar with. These include areas that you have done more detailed project work on or localized studies.

If necessary follow up with field visits to areas that are confused and correct labels cannot be easily determined.

The next sections provide a description of reviewing digital maps.

<u>Digital draft map review procedures:</u>

Digital versions of the draft map are available through webmap. It is important to review the general distribution and extent of vegetation patterns at a scale that corresponds to the midlevel mapping scale, e.g. 1:50,000 to 1:100,000. To access the map layers use the following directions.

Webmap instructions:

Open webmap. Go to: http://166.2.126.175/Sawtooth/

A web browser will open, click on the OK button and the map will be displayed automatically. There are four buttons at the top of the screen, just to the right of center. These buttons from left to right are: Layer List, Veg Type Map Legend, Identify, Swipe Spotlight, Edit, and Print. The legend can be activated and deactivated by clicking on legend icon.

Making Edits to the map. Use the editing widget to draw polygons for areas where changes need to be made or where you see the map not following the pattern of the landscape. To begin making edits click on the editing widget. An Edit window will open. Select the map unit class you wish to place on the map. Select a drawing tool (in the lower right of the edit window) and begin digitizing on the map. After the edit is complete, an attribute box will appear. Here you will enter your name for edit tracking. Full polygon editing is available for point to point and freehand. The lower left of the editing window has tools to make selections for deleting edit features if needed.

Saving edits to the map. Your changes will be automatically saved to the server at RSAC when you close the webmap session.

Additional notes on using webmap:

More…

Use the slider underneath each layer to adjust the transparency.

Static legend: Toggle the map legend on and off.

Editing Tools: This opens the editing interface.

Additional tools: Similar to tools in ArcMap, there is identify and print tools.

Different backgrounds are available to view as reference (imagery, streets, topographic, etc.). These are available on the top right corner of the webpage under the Basemap button located in the upper right-hand corner.

Navigation tools are on the left side of the map. Additionally you can use keyboard arrows, mouse panning with click and drag, and the scroll wheel on the mouse to zoom

District Questions & Observations:

This section provides specific questions and observations about the vegetation maps for each district.

<u>Sawtooth NRA and Wilderness:</u>

Is anyone familiar with a few Subalpine Fir – Whitebark Pine and Whitebark Pine Mix areas that we can compare the map to?

Is anyone familiar with a few Alpine Vegetation areas that we can compare the map to?

Are there any areas of Aspen, Aspen/Conifer Mix, or Conifer/Aspen Mix that are not mapped accordingly? (I asked this in the previous review, but I want to see if there is any further input).

<u>Fairfield District:</u>

Is there Ponderosa Pine along Lime Creek (east of Anderson Ranch Reservoir?

Does the scattered amount of Subalpine Fir – Whitebark Pine and Whitebark Pine Mix around the Soldier Mountains/ Smoky Dome area look reasonable?

Are there any other areas of dominant Bitterbrush that are not mapped as Bitterbrush? (Some edits have been made to the WebMap already; I just want to see if there are any other areas).

<u>Ketchum District:</u>

There is almost no Engelmann Spruce mapped in this district, does that reflect reality?

In the areas where Douglas-fir transitions to Subalpine Fir - Douglas-fir, does the transition seem to take place in about the right area/elevation?

<u>Minidoka:</u>

How does the extent of Pinyon look in the mapped location (On the Southwest end of the Black Pine Mountains)?

Mt Harrison peak is mapped as *Grass*, is this alpine vegetation or is it actually grass (350 or so acres)?

References:

Brohamn, R.; Bryant L. editors. 2005. Existing vegetation classification and mapping technical guide. Gen Tech. Rep. WO-67. Washington DC: U.S. Department of Agriculture, Forest Service, Ecosystem Management Coordination Staff. 305 p.

Tuxen, R. 1956. Die heutige naturliche potentielle Vegetation als Gegenstand der vegetation-skartierung. Remagen. Berichtze zur Deutschen Landekunde. 19:200-246.

Appendix H: Merge Rules for Segments Less Than MMF Size

Vegetation Types:

- Aspen AS
- Aspen/Conifer AS/C
- Conifer/Aspen C/AS
- Douglas-fir DF
- Douglas-fir - Lodgepole Pine DFL
- Engelmann Spruce ES
- Lodgepole Pine LP
- Ponderosa Pine PP
- Subalpine Fir SA
- Subalpine Fir – Douglas-fir SAD
- Subalpine Fir – Whitebark Pine SAW
- Whitebark Pine Mix WBmix
- Mountain Mahogany MM
- Pinyon-Juniper PJ
- Utah Juniper UJ
- Bitterbrush BB
- Dwarf Sagebrush DSB
- Mountain Big Sagebrush MSB
- Wyoming Big Sagebrush WSB
- Forest Shrubland FS
- Mountain Shrubland MS
- Alpine Vegetation ALP
- Forbland FO
- Grassland GR
- Riparian Shrubland and Deciduous Forest RSH
- Riparian Herbaceous RHE
- Agriculture AGR
- Barren/Sparse Vegetation BR/SV
- Developed DEV
- Water WA

Deciduous group	= AS, AS/C, C/AS
Conifer group	= DF, DFL, ES, LP, PP, SA, SAD, SAW, WBmix
Woodland group	= MM, PJ, UJ
Xeric Shrub group	= BB, DSB, MSB, WSB
FMSH Shrub group	= FS, MS
Herbaceous group	= FO, GR
Riparian group	= RSH, RHE
Barren/Sparse Veg	= BR/SV
Other	= AGR, DEV (no minimum size, no filter, nothing filtering into it)
Water	= WA (no minimum size, no filter, nothing filtering into it)

Forest Types

<u>Aspen (2 acre MMF)</u>

1. Aspen/Conifer
2. Conifer/Aspen
3. Forest Shrubland

4. Mountain Shrubland
5. Douglas-fir
6. Douglas-fir - Lodgepole Pine
7. Lodgepole Pine
8. Engelmann Spruce
9. Ponderosa Pine
10. Subalpine Fir – Douglas-fir
11. Subalpine Fir
12. Subalpine Fir - Whitebark Pine
13. Whitebark Pine Mix
14. Woodland group
15. Xeric Shrub group
16. Riparian Shrubland and Deciduous Forest
17. Riparian Herbaceous
18. Herbaceous group
19. Alpine Vegetation
20. Barren/Sparse Vegetation
21. Developed
22. Agriculture
23. Water

Aspen/Conifer (2 acre MMF)

1. Conifer/Aspen
2. Aspen
3. Forest Shrubland
4. Mountain Shrubland
5. Douglas-fir
6. Douglas-fir - Lodgepole Pine
7. Lodgepole Pine
8. Engelmann Spruce
9. Ponderosa Pine
10. Subalpine Fir – Douglas-fir
11. Subalpine Fir
12. Subalpine Fir - Whitebark Pine
13. Whitebark Pine Mix
14. Woodland group
15. Riparian Shrubland and Deciduous Forest
16. Riparian Herbaceous
17. Herbaceous group
18. Xeric Shrub group
19. Alpine Vegetation
20. Barren/Sparse Vegetation

21. Developed
22. Agriculture
23. Water

Conifer/Aspen (2 acre MMF)

1. Aspen/Conifer
2. Aspen
3. Douglas-fir
4. Douglas-fir - Lodgepole Pine
5. Lodgepole Pine
6. Engelmann Spruce
7. Ponderosa Pine
8. Subalpine Fir – Douglas-fir
9. Subalpine Fir
10. Subalpine Fir - Whitebark Pine
11. Whitebark Pine Mix
12. Forest Shrubland
13. Mountain Shrubland
14. Woodland group
15. Riparian Shrubland and Deciduous Forest
16. Riparian Herbaceous
17. Herbaceous group
18. Xeric Shrub group
19. Alpine Vegetation
20. Barren/Sparse Vegetation
21. Developed
22. Agriculture
23. Water

Douglas-fir

1. Douglas-fir – Lodgepole Pine
2. Subalpine Fir – Douglas-fir
3. Ponderosa Pine
4. Lodgepole Pine
5. Subalpine Fir
6. Engelmann Spruce
7. Subalpine Fir – Whitebark Pine
8. Whitebark Pine Mix
9. Conifer/Aspen
10. Aspen/Conifer
11. Mountain Mahogany
12. Pinyon-Juniper

13. Utah Juniper
14. Aspen
15. Forest Shrubland
16. Mountain Shrubland
17. Mountain Big Sagebrush
18. Bitterbrush
19. Wyoming Big Sagebrush
20. Dwarf Sagebrush
21. Herbaceous group
22. Barren/Sparse Vegetation
23. Riparian Shrubland and Deciduous Forest
24. Riparian Herbaceous
25. Alpine Vegetation
26. Developed
27. Agriculture
28. Water

<u>Douglas-fir – Lodgepole Pine</u>

1. Douglas-fir
2. Lodgepole Pine
3. Subalpine Fir – Douglas-fir
4. Subalpine Fir
5. Engelmann Spruce
6. Subalpine Fir – Whitebark Pine
7. Conifer/Aspen
8. Ponderosa Pine
9. Aspen/Conifer
10. Aspen
11. Mountain Mahogany
12. Pinyon-Juniper
13. Utah Juniper
14. Whitebark Pine Mix
15. Forest Shrubland
16. Mountain Shrubland
17. Mountain Big Sagebrush
18. Bitterbrush
19. Wyoming Big Sagebrush
20. Dwarf Sagebrush
21. Herbaceous group
22. Barren/Sparse Vegetation
23. Riparian Shrubland and Deciduous Forest
24. Riparian Herbaceous

25. Alpine Vegetation
26. Developed
27. Agriculture
28. Water

Engelmann Spruce (Some South classes not listed because ES only occurs on North)

1. Subalpine Fir
2. Subalpine Fir – Douglas-fir
3. Subalpine Fir – Whitebark Pine
4. Whitebark Pine Mix
5. Lodgepole Pine
6. Douglas-fir – Lodgepole Pine
7. Douglas-fir
8. Riparian Shrubland and Deciduous Forest
9. Conifer/Aspen
10. Aspen/Conifer
11. Aspen
12. Ponderosa Pine
13. Forest Shrubland
14. Mountain Shrubland
15. Mountain Big Sagebrush
16. Bitterbrush
17. Wyoming Big Sagebrush
18. Riparian Herbaceous
19. Dwarf Sagebrush
20. Herbaceous group
21. Alpine Vegetation
22. Barren/Sparse Vegetation
23. Water
24. Developed
25. Agriculture

Lodgepole Pine

1. Douglas-fir – Lodgepole Pine
2. Douglas-fir
3. Subalpine Fir
4. Engelmann Spruce
5. Subalpine Fir – Douglas-fir
6. Subalpine Fir – Whitebark Pine
7. Whitebark Pine Mix
8. Conifer/Aspen

9. Aspen/Conifer
10. Ponderosa Pine
11. Aspen
12. Mountain Mahogany
13. Pinyon-Juniper
14. Utah Juniper
15. Forest Shrubland
16. Mountain Shrubland
17. Mountain Big Sagebrush
18. Bitterbrush
19. Wyoming Big Sagebrush
20. Dwarf Sagebrush
21. Riparian Shrubland and Deciduous Forest
22. Herbaceous group
23. Riparian Herbaceous
24. Alpine Vegetation
25. Barren/Sparse Vegetation
26. Developed
27. Agriculture
28. Water

Ponderosa Pine (Some South classes not listed because PP only occurs on North)

1. Douglas-fir
2. Douglas-fir – Lodgepole Pine
3. Lodgepole Pine
4. Subalpine Fir – Douglas-fir
5. Conifer/Aspen
6. Aspen/Conifer
7. Aspen
8. Engelmann Spruce
9. Subalpine Fir
10. Subalpine Fir – Whitebark Pine
11. Whitebark Pine Mix
12. Forest Shrubland
13. Mountain Shrubland
14. Mountain Big Sagebrush
15. Bitterbrush
16. Wyoming Big Sagebrush
17. Dwarf Sagebrush
18. Herbaceous group
19. Riparian Shrubland and Deciduous Forest
20. Riparian Herbaceous

21. Alpine Vegetation
22. Developed
23. Barren/Sparse Vegetation
24. Agriculture
25. Water

Subalpine Fir

1. Subalpine Fir – Whitebark Pine
2. Subalpine Fir – Douglas-fir
3. Whitebark Pine Mix
4. Engelmann Spruce
5. Lodgepole Pine
6. Douglas-fir – Lodgepole Pine
7. Douglas-fir
8. Conifer/Aspen
9. Aspen/Conifer
10. Aspen
11. Ponderosa Pine
12. Forest Shrubland
13. Mountain Shrubland
14. Mountain Big Sagebrush
15. Bitterbrush
16. Forbland
17. Grassland
18. Pinyon-Juniper
19. Mountain Mahogany
20. Utah Juniper
21. Dwarf Sagebrush
22. Alpine Vegetation
23. Barren/Sparse Vegetation
24. Riparian Shrubland and Deciduous Forest
25. Riparian Herbaceous
26. Wyoming Big Sagebrush
27. Developed
28. Agriculture
29. Water

Subalpine Fir – Douglas-fir (Some South classes not listed because SAD only occurs on North)

1. Subalpine Fir
2. Douglas-fir
3. Subalpine Fir – Whitebark Pine
4. Whitebark Pine Mix

5. Douglas-fir – Lodgepole Pine
6. Engelmann Spruce
7. Lodgepole Pine
8. Conifer/Aspen
9. Aspen/Conifer
10. Aspen
11. Ponderosa Pine
12. Forest Shrubland
13. Mountain Shrubland
14. Mountain Big Sagebrush
15. Bitterbrush
16. Dwarf Sagebrush
17. Forbland
18. Grassland
19. Alpine Vegetation
20. Barren/Sparse Vegetation
21. Riparian Shrubland and Deciduous Forest
22. Riparian Herbaceous
23. Wyoming Big Sagebrush
24. Developed
25. Agriculture
26. Water

<u>Subalpine Fir – Whitebark Pine (Some South classes not listed because SAW only occurs on North)</u>

1. Whitebark Pine Mix
2. Subalpine Fir
3. Subalpine Fir – Douglas-fir
4. Engelmann Spruce
5. Lodgepole Pine
6. Douglas-fir – Lodgepole Pine
7. Douglas-fir
8. Conifer/Aspen
9. Aspen/Conifer
10. Aspen
11. Ponderosa Pine
12. Forest Shrubland
13. Mountain Shrubland
14. Mountain Big Sagebrush
15. Bitterbrush
16. Dwarf Sagebrush
17. Forbland
18. Grassland

19. Alpine Vegetation
20. Barren/Sparse Vegetation
21. Riparian Shrubland and Deciduous Forest
22. Riparian Herbaceous
23. Wyoming Big Sagebrush
24. Developed
25. Agriculture
26. Water

Whitebark Pine Mix (Some South classes not listed because WBmix only occurs on North)

1. Subalpine Fir – Whitebark Pine
2. Subalpine Fir
3. Engelmann Spruce
4. Lodgepole Pine
5. Subalpine Fir – Douglas-fir
6. Douglas-fir – Lodgepole Pine
7. Douglas-fir
8. Conifer/Aspen
9. Aspen/Conifer
10. Aspen
11. Ponderosa Pine
12. Forest Shrubland
13. Mountain Shrubland
14. Mountain Big Sagebrush
15. Bitterbrush
16. Dwarf Sagebrush
17. Forbland
18. Grassland
19. Alpine Vegetation
20. Barren/Sparse Vegetation
21. Riparian Shrubland and Deciduous Forest
22. Riparian Herbaceous
23. Wyoming Big Sagebrush
24. Developed
25. Agriculture
26. Water

Mountain Mahogany (Some North classes not listed because MM only occurs on North)

1. Pinyon-Juniper
2. Utah Juniper
3. Ponderosa Pine
4. Douglas-fir

5. Douglas-fir – Lodgepole Pine
6. Lodgepole Pine
7. Mountain Shrubland
8. Forest Shrubland
9. Mountain Big Sagebrush
10. Bitterbrush
11. Dwarf Sagebrush
12. Wyoming Big Sagebrush
13. Subalpine Fir
14. Conifer/Aspen
15. Aspen/Conifer
16. Aspen
17. Herbaceous group
18. Barren/Sparse Vegetation
19. Riparian Shrubland and Deciduous Forest Service
20. Alpine Vegetation
21. Developed
22. Agriculture
23. Water

<u>Pinyon-Juniper (Some North classes not listed because PJ only occurs on North)</u>

1. Utah Juniper
2. Mountain Mahogany
3. Ponderosa Pine
4. Douglas-fir
5. Douglas-fir – Lodgepole Pine
6. Lodgepole Pine
7. Mountain Shrubland
8. Forest Shrubland
9. Mountain Big Sagebrush
10. Bitterbrush
11. Dwarf Sagebrush
12. Wyoming Big Sagebrush
13. Subalpine Fir
14. Conifer/Aspen
15. Aspen/Conifer
16. Aspen
17. Herbaceous group
18. Barren/Sparse Vegetation
19. Riparian Shrubland and Deciduous Forest Service
20. Alpine Vegetation
21. Developed

22. Agriculture
23. Water

<u>Utah Juniper (Some North classes not listed because UJ only occurs on North)</u>

1. Pinyon - Juniper
2. Mountain Mahogany
3. Ponderosa Pine
4. Douglas-fir
5. Douglas-fir – Lodgepole Pine
6. Lodgepole Pine
7. Mountain Shrubland
8. Forest Shrubland
9. Mountain Big Sagebrush
10. Bitterbrush
11. Dwarf Sagebrush
12. Wyoming Big Sagebrush
13. Subalpine Fir
14. Conifer/Aspen
15. Aspen/Conifer
16. Aspen
17. Herbaceous group
18. Barren/Sparse Vegetation
19. Riparian Shrubland and Deciduous Forest Service
20. Alpine Vegetation
21. Developed
22. Agriculture
23. Water

Bitterbrush

1. Mountain Big Sagebrush
2. Mountain Shrubland
3. Forest Shrubland
4. Dwarf Sagebrush
5. Wyoming Big Sagebrush
6. Mountain Mahogany
7. Utah Juniper
8. Pinyon-Juniper
9. Grassland
10. Forbland
11. Barren/Sparse Vegetation
12. Ponderosa Pine
13. Douglas-fir
14. Douglas-fir - Lodgepole Pine
15. Lodgepole Pine
16. Aspen
17. Aspen/Conifer
18. Conifer/Aspen
19. Subalpine Fir – Douglas-fir
20. Subalpine Fir
21. Engelmann Spruce
22. Riparian Shrubland and Deciduous Forest
23. Riparian Herbaceous
24. Subalpine Fir – Whitebark Pine
25. Whitebark Pine Mix
26. Alpine Vegetation
27. Developed
28. Agriculture
29. Water

Dwarf Sagebrush

1. Mountain Big Sagebrush
2. Wyoming Big Sagebrush
3. Bitterbrush
4. Mountain Shrubland
5. Forest Shrubland
6. Grassland
7. Forbland
8. Barren/Sparse Vegetation
9. Mountain Mahogany
10. Pinyon-Juniper

11. Utah Juniper
12. Ponderosa Pine
13. Douglas-fir
14. Douglas-fir - Lodgepole Pine
15. Lodgepole Pine
16. Aspen
17. Aspen/Conifer
18. Conifer/Aspen
19. Subalpine Fir – Douglas-fir
20. Subalpine Fir
21. Engelmann Spruce
22. Riparian Shrubland and Deciduous Forest
23. Riparian Herbaceous
24. Subalpine Fir – Whitebark Pine
25. Whitebark Pine Mix
26. Alpine Vegetation
27. Developed
28. Agriculture
29. Water

<u>Mountain Big Sagebrush</u>

1. Bitterbrush
2. Mountain Shrubland
3. Dwarf Sagebrush
4. Forest Shrubland
5. Grassland
6. Forbland
7. Wyoming Big Sagebrush
8. Barren/Sparse Vegetation
9. Mountain Mahogany
10. Pinyon-Juniper
11. Utah Juniper
12. Douglas-fir
13. Douglas-fir - Lodgepole Pine
14. Ponderosa Pine
15. Lodgepole Pine
16. Aspen
17. Aspen/Conifer
18. Conifer/Aspen
19. Alpine Vegetation
20. Subalpine Fir – Douglas-fir
21. Subalpine Fir

22. Engelmann Spruce
23. Riparian Shrubland and Deciduous Forest
24. Riparian Herbaceous
25. Subalpine Fir – Whitebark Pine
26. Whitebark Pine Mix
27. Developed
28. Agriculture
29. Water

Wyoming Big Sagebrush

1. Dwarf Sagebrush
2. Bitterbrush
3. Mountain Big Sagebrush
4. Grassland
5. Forbland
6. Mountain Shrubland
7. Forest Shrubland
8. Barren/Sparse Vegetation
9. Utah Juniper
10. Pinyon-Juniper
11. Mountain Mahogany
12. Ponderosa Pine
13. Douglas-fir
14. Douglas-fir - Lodgepole Pine
15. Lodgepole Pine
16. Aspen
17. Aspen/Conifer
18. Conifer/Aspen
19. Alpine Vegetation
20. Subalpine Fir – Douglas-fir
21. Subalpine Fir
22. Engelmann Spruce
23. Riparian Shrubland and Deciduous Forest
24. Riparian Herbaceous
25. Subalpine Fir – Whitebark Pine
26. Whitebark Pine Mix
27. Developed
28. Agriculture
29. Water

Forest Shrubland

1. Mountain Shrubland

2. Mountain Big Sagebrush
3. Bitterbrush
4. Dwarf Sagebrush
5. Wyoming Big Sagebrush
6. Grassland
7. Forbland
8. Mountain Mahogany
9. Pinyon-Juniper
10. Utah Juniper
11. Ponderosa Pine
12. Douglas-fir
13. Douglas-fir - Lodgepole Pine
14. Lodgepole Pine
15. Aspen
16. Aspen/Conifer
17. Conifer/Aspen
18. Alpine Vegetation
19. Subalpine Fir – Douglas-fir
20. Subalpine Fir
21. Engelmann Spruce
22. Barren/Sparse Vegetation
23. Riparian Shrubland and Deciduous Forest
24. Riparian Herbaceous
25. Subalpine Fir – Whitebark Pine
26. Whitebark Pine Mix
27. Developed
28. Agriculture
29. Water

<u>Mountain Shrubland</u>

1. Forest Shrubland
2. Mountain Big Sagebrush
3. Bitterbrush
4. Dwarf Sagebrush
5. Wyoming Big Sagebrush
6. Grassland
7. Forbland
8. Mountain Mahogany
9. Pinyon-Juniper
10. Utah Juniper
11. Ponderosa Pine
12. Douglas-fir

13. Douglas-fir - Lodgepole Pine
14. Lodgepole Pine
15. Aspen
16. Aspen/Conifer
17. Conifer/Aspen
18. Alpine Vegetation
19. Subalpine Fir – Douglas-fir
20. Subalpine Fir
21. Engelmann Spruce
22. Barren/Sparse Vegetation
23. Riparian Shrubland and Deciduous Forest
24. Riparian Herbaceous
25. Subalpine Fir – Whitebark Pine
26. Whitebark Pine Mix
27. Developed
28. Agriculture
29. Water

<u>Alpine Vegetation</u>

1. Barren/Sparse Vegetation
2. Forbland
3. Grassland
4. Dwarf Sagebrush
5. Mountain Big Sagebrush
6. Bitterbrush
7. Mountain Shrubland
8. Forest Shrubland
9. Whitebark Pine Mix
10. Subalpine Fir – Whitebark Pine
11. Subalpine Fir
12. Engelmann Spruce
13. Douglas-fir – Lodgepole Pine
14. Lodgepole Pine
15. Subalpine Fir – Douglas-fir
16. Douglas-fir
17. Conifer/Aspen
18. Aspen/Conifer
19. Aspen
20. Riparian Herbaceous
21. Riparian Shrubland and Deciduous Forest
22. Ponderosa Pine
23. Mountain Mahogany

24. Pinyon-Juniper
25. Utah Juniper
26. Wyoming Big Sagebrush
27. Developed
28. Agriculture
29. Water

Forbland (Some South classes not listed because FO only occurs on North)

1. Grassland
2. Alpine Vegetation
3. Mountain Big Sagebrush
4. Bitterbrush
5. Wyoming Big Sagebrush
6. Dwarf Sagebrush
7. Mountain Shrub
8. Forest Shrub
9. Barren/Sparse Vegetation
10. Riparian Herbaceous
11. Riparian Shrubland and Deciduous Forest
12. Conifer group
13. Deciduous group
14. Developed
15. Agriculture
16. Water

Grassland

1. Forbland
2. Alpine Vegetation
3. Mountain Big Sagebrush
4. Bitterbrush
5. Wyoming Big Sagebrush
6. Dwarf Sagebrush
7. Mountain Shrub
8. Forest Shrub
9. Barren/Sparse Vegetation
10. Riparian Herbaceous
11. Woodland group
12. Riparian Shrubland and Deciduous Forest
13. Conifer group
14. Deciduous group
15. Developed
16. Agriculture

17. Water

<u>Riparian Woody (2 acre MMF, all of these types were assigned a shrub canopy cover)</u>

1. Riparian Herbaceous
2. Engelmann Spruce
3. Aspen
4. Aspen/Conifer
5. Conifer/Aspen
6. Lodgepole Pine
7. Douglas-fir - Lodgepole Pine
8. Douglas-fir
9. Subalpine Fir – Douglas-fir
10. Subalpine Fir
11. Ponderosa Pine
12. Forest Shrubland
13. Mountain Shrubland
14. Mountain Big Sagebrush
15. Bitterbrush
16. Subalpine Fir – Whitebark Pine
17. Whitebark Pine Mix
18. Alpine Vegetation
19. Herbaceous group
20. Woodland group
21. Wyoming Big Sagebrush
22. Dwarf Sagebrush
23. Barren/Sparse Vegetation
24. Developed
25. Agriculture
26. Water

<u>Riparian Herbaceous (2 acre MMF) (Some South classes not listed because RHE only occurs on North)</u>

1. Riparian Shrubland and Deciduous Forest
2. Herbaceous group
3. Alpine Vegetation
4. Forest Shrubland
5. Mountain Shrubland
6. Mountain Big Sagebrush
7. Dwarf Sagebrush
8. Aspen
9. Aspen/Conifer
10. Conifer/Aspen
11. Engelmann Spruce

12. Lodgepole Pine
13. Douglas-fir - Lodgepole Pine
14. Douglas-fir
15. Subalpine Fir – Douglas-fir
16. Subalpine Fir
17. Ponderosa Pine
18. Subalpine Fir – Whitebark Pine
19. Bitterbrush
20. Whitebark Pine Mix
21. Barren/Sparse Vegetation
22. Developed
23. Agriculture
24. Water

<u>Barren/Sparse Vegetation</u>

1. Alpine Vegetation
2. Herbaceous group
3. Xeric Shrub group
4. FMSH Shrub group
5. Woodland group
6. Whitebark Pine Mix
7. Subalpine Fir – Whitebark Pine
8. Lodgepole Pine
9. Douglas-fir - Lodgepole Pine
10. Douglas-fir
11. Conifer group
12. Deciduous group
13. Riparian Herbaceous
14. Riparian Shrubland and Deciduous Forest
15. Developed
16. Agriculture
17. Water

Canopy Cover Classes

Filtering Rules: 5 acres (except where otherwise noted)

<u>Tree canopy 1</u>

- Tree canopy 2
- Tree canopy 3
- Tree canopy 4

<u>Tree canopy 2</u>

- Tree canopy 3
- Tree canopy 1
- Tree canopy 4

<u>Tree canopy 3</u>

- Tree canopy 4
- Tree canopy 2
- Tree canopy 1

<u>Tree canopy 4</u>

- Tree canopy 3
- Tree canopy 2
- Tree canopy 1

<u>Aspen, Aspen/Conifer, Conifer/Aspen Tree canopy 1 (2 acres)</u>

- Aspen, Aspen/Conifer, Conifer/Aspen Tree canopy 2
- Aspen, Aspen/Conifer, Conifer/Aspen Tree canopy 3
- Aspen, Aspen/Conifer, Conifer/Aspen Tree canopy 4
-

<u>Aspen, Aspen/Conifer, Conifer/Aspen Tree canopy 2 (2 acres)</u>

- Aspen, Aspen/Conifer, Conifer/Aspen Tree canopy 3
- Aspen, Aspen/Conifer, Conifer/Aspen Tree canopy 1
- Aspen, Aspen/Conifer, Conifer/Aspen Tree canopy 4

<u>Aspen, Aspen/Conifer, Conifer/Aspen Tree canopy 3 (2 acres)</u>

- Aspen, Aspen/Conifer, Conifer/Aspen Tree canopy 4
- Aspen, Aspen/Conifer, Conifer/Aspen Tree canopy 2
- Aspen, Aspen/Conifer, Conifer/Aspen Tree canopy 1

<u>Aspen, Aspen/Conifer, Conifer/Aspen Tree canopy 4 (2 acres)</u>

- Aspen, Aspen/Conifer, Conifer/Aspen Tree canopy 3
- Aspen, Aspen/Conifer, Conifer/Aspen Tree canopy 2
- Aspen, Aspen/Conifer, Conifer/Aspen Tree canopy 1

<u>Shrub canopy 1</u>

- Shrub canopy 2
- Shrub canopy 3
- Shrub canopy 4

<u>Shrub canopy 2</u>

- Shrub canopy 1
- Shrub canopy 3
- Shrub canopy 4

<u>Shrub canopy 3</u>

- Shrub canopy 2
- Shrub canopy 4
- Shrub canopy 1

<u>Riparian Woody canopy 1 (2 acres)</u>

- Riparian Vegetation canopy 2
- Riparian Vegetation canopy 3
- Riparian Vegetation canopy 4

<u>Riparian Woody canopy 2 (2 acres)</u>

- Riparian Vegetation canopy 1
- Riparian Vegetation canopy 3
- Riparian Vegetation canopy 4

<u>Riparian Woody canopy 3 (2 acres)</u>

- Riparian Vegetation canopy 2
- Riparian Vegetation canopy 4
- Riparian Vegetation canopy 1

<u>Riparian Woody canopy 4 (2 acres)</u>

- Riparian Vegetation canopy 3
- Riparian Vegetation canopy 2
- Riparian Vegetation canopy 1

Tree Size Classes

Filtering Rules: 5 acres (except where otherwise noted)

Forest tree size 1

- Forest tree size 2
- Forest tree size 3
- Forest tree size 4

Forest tree size 2

- Forest tree size 3
- Forest tree size 1
- Forest tree size 4

Forest tree size 3

- Forest tree size 4
- Forest tree size 2
- Forest tree size 1

Forest tree size 4

- Forest tree size 3
- Forest tree size 2
- Forest tree size 1

Aspen, Aspen/Conifer, Conifer/Aspen Tree size 1 (2 acres)

- Aspen, Aspen/Conifer, Conifer/Aspen Tree size 2
- Aspen, Aspen/Conifer, Conifer/Aspen Tree size 3
- Aspen, Aspen/Conifer, Conifer/Aspen Tree size 4

Aspen, Aspen/Conifer, Conifer/Aspen Tree size 2 (2 acres)

- Aspen, Aspen/Conifer, Conifer/Aspen Tree size 3
- Aspen, Aspen/Conifer, Conifer/Aspen Tree size 1
- Aspen, Aspen/Conifer, Conifer/Aspen Tree size 4

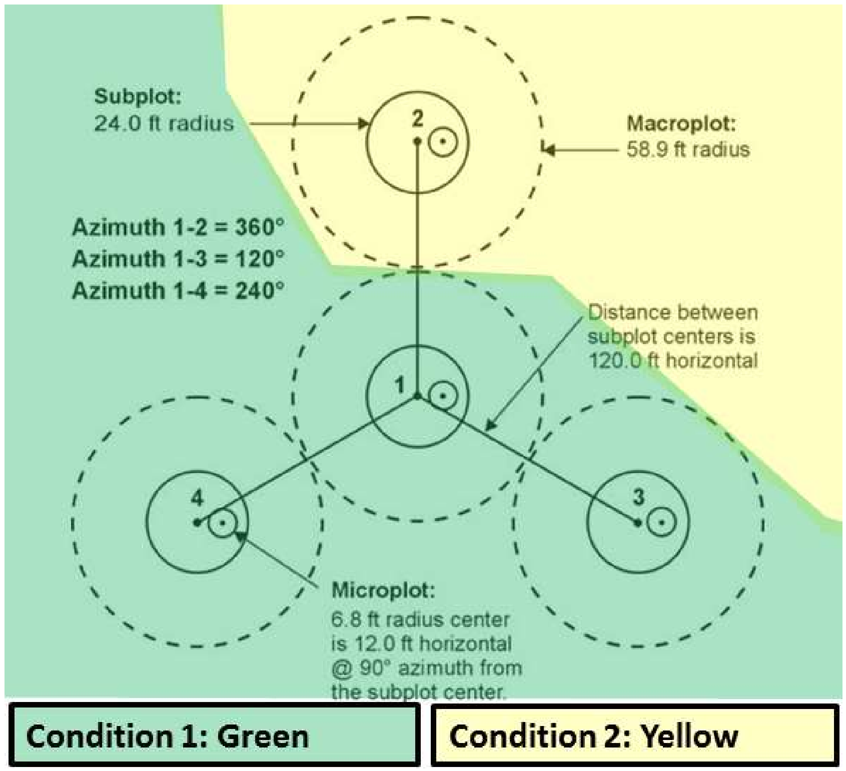
Aspen, Aspen/Conifer, Conifer/Aspen Tree size 3 (2 acres)

- Aspen, Aspen/Conifer, Conifer/Aspen Tree size 4
- Aspen, Aspen/Conifer, Conifer/Aspen Tree size 2
- Aspen, Aspen/Conifer, Conifer/Aspen Tree size 1

Aspen, Aspen/Conifer, Conifer/Aspen Tree size 4 (2 acres)

- Aspen, Aspen/Conifer, Conifer/Aspen Tree size 3
- Aspen, Aspen/Conifer, Conifer/Aspen Tree size 2
- Aspen, Aspen/Conifer, Conifer/Aspen Tree size 1

Appendix I: Diagram of an FIA Plot



A schematic of an FIA plot showing the four subplots. In some cases, a condition change may occur on a plot, thereby giving multiple conditions to a single plot. The schematic shows an example in which subplots 1, 3 and 4 are within condition 1, while subplot 2 is located within condition 2. Schematic source: USFS Forest Inventory and Analysis Program.